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1 Introduction

The pressure on companies to respond flexibly to market changes has increased significantly over the last years. This external pressure also affects in-house infrastructures of information technology (IT) (Bieberstein et al. 2006, p. 1). Divisions and departments within a company therefore need specific, flexible, and unique solutions, which has led to a considerable amount of decentralization within IT infrastructures in the past.

In recent years, this development induced the evolution of so-called IT silos, in which applications are bound to specific servers or infrastructures (Foster and Tuecke 2005, p. 28). In order to offer enough computing power within peak times, extensive resources have to be available. Thus, idle system time can account for almost 90% of total uptime. The unused hardware consequently ties up enormous amounts of capital that cannot be invested profitably otherwise (Carr 2005). In addition, further investments to expand the existing infrastructure for economic growth also call for financial resources. Companies lacking these resources are inhibited from responding flexibly to computing demands. Therefore, IT has become a substantial competitive factor.

In this situation, Grid computing offers to integrate hardware horizontally and share (geographically) distributed resources within or beyond the boundaries of the individual enterprise (Foster and Kesselman 2004). Through Grid computing, companies can dynamically buy additional computing resources or make unused processing time, storage, services or applications available. The capital lockup can be reduced and resources can be used more flexibly.

Within a company, available resources are highly limited. Since Grid computing started in the scientific world, where resource sharing across geographical and institutional boundaries is essential for research purposes, the interest to apply the approach of pervasive computing—the open Grid—to business purposes has increased significantly. Within such an open network of Grid computing, a large number of different resources can be made available between any interested party (Plaszczak and Wellner 2006).

In this context, the EU-funded project SORMA (Self-Organizing ICT Resource Management) is developing an open market platform for Grid resources. Using this technology, excess capacities can be offered and additional demand for computing power can be satisfied automatically—within and across organizational boundaries (Neumann et al. 2007). This research project originated within this context.

To date, the utilization of Grid functionalities is still limited. For this reason, businesses need support in analyzing business issues of Grid computing (Thanos et al. 2007) and possible business models (Altmann et al. 2007). Since subjective assessments are important factors that influence the decision to adopt a technology and especially open Grid resources (Hwang and Park 2007), the contribution of this paper to ongoing research is to examine corporate attitudes more closely. Two specific issues arise: the management and evaluation of IT-related costs and the perceived security challenges within an open Grid environment. An explorative survey was conducted to analyze possible requirements and influential factors of an open Grid platform. This approach specifically focuses on the attitude of experienced individuals within existing Grid networks. In the course of this paper, the findings of the conducted study will be generalized and applied to open Grids. As a result, hypotheses will be elaborated and a theoretical model of determinants for the adoption of open Grid resources will be proposed. This model can then be assessed theoretically and practically in order to deal with potentially unsubstantiated subjective objections (Carr 2005, p. 71) against the adoption of Grid platforms in general and to enhance an existing open Grid platform in order to accelerate its diffusion.

Following this introduction (Chapter 1), the existing Grid market will be analyzed in Chapter 2. After an introduction to Grid computing in general, the market, its participants, and determinants of the diffusion process are observed from a theoretical perspective. Then, the focus will be on the key issues of economic and security-related aspects.

Chapter 3 concentrates on the methodology of the conducted research. The questionnaire as well as the conduction of the survey and the analysis of the data will be described here.

The results of this study will be summarized in Chapter 4. The description and analysis will specifically focus on the structure and relationship between the items respectively the responses depending on company size and business purpose (private versus public sector).

Chapter 5 then discusses the obtained results. Derived from these results, a theoretical model of determinants for the intention to adopt open Grid resources will be proposed. The limitations of this study will be outlined and practical implications will be given.

A conclusion and a summary in Chapter 6 will close this paper.

2 Theoretical Background

2.1 Term Definition and Classification

2.1.1 Grid Computing

Although many attempts have been undertaken to define the term Grid Computing, no common definition has become prevalent until today. Nevertheless, the elaborations of Foster (2002) et al. (2001; 2004) seem to become the de facto standard. I will therefore follow their definition and redefinitions at first and elaborate important and missing parts regarding business issues subsequently.

The term Grid computing was originally used in the mid 1990s for an advanced distributed computing structure (Foster et al. 2001) although the vision of computing power as a commodity—comparable to the electricity or water grid—was already mentioned in the mid 1960s (Vyssotsky et al. 1965). After several redefinitions (Foster and Kesselman 1999; Foster et al. 2001), Foster (2002, pp. 2-3) therefore stated in a three-point checklist that

> "a Grid is a system that:
>
> 1. coordinates resources that are not subject to centralized control […]

2. … using standard, open, general-purpose protocols and interfaces […]
3. … to deliver nontrivial qualities of service (QoS) […]".

From this definition it can be concluded that Grid computing is concerned with direct access to heterogeneous resources through standard, open, general-purpose protocols. Furthermore, "the goal [of Grid computing] is to provide a service-oriented infrastructure that leverages standardized protocols and services to enable pervasive access to and coordinated sharing of geographically distributed hardware, software, and information resources" (Parashar and Lee 2005, p. 479). Services as small, reusable agents (Joseph and Fellenstein 2004, p. 64) can therefore be seamlessly integrated in order to create new and flexible functionalities that become necessary e.g. in a rapidly changing business environment. The mentioned standards provide the needed interoperability of resources and services for collaboration across multiple control domains. A thorough description of the underlying Grid architecture and its standards can be found in Foster et al. (2002b).

Dynamic "virtual organizations" (VOs) (Foster et al. 2001) are a key element within the described sharing environment. The policies of the virtual organization therefore constitute one common trust domain for individuals, groups or organizations from diverse administrative domains with differing degrees of prior relationship (Foster et al. 2001, pp. 200-201; Welch et al. 2003). Thus, participants of VOs can be part of various VOs and may offer various resources, each with different rules and conditions for usage according to the respective VO. Moreover, VOs enable its members to increase their productivity as they can resort to a significantly greater number of resources or specialized equipment (Humphrey et al. 2005, p. 644). Foster et al. (2001, p. 204) therefore view the concept of dynamically-scalable VOs fundamental for future computing.

For this reason, Grid computing does not only offer the possibility to solve computationally intensive tasks. The horizontal integration of IT silos, where applications rely on specific hardware, and distributed resources seems to be especially rewarding for companies (Carr 2005). Thus, IT assets can be combined to increase already existing low utility rates of e.g. 15-35% of available processing power within data centers (Andrzejak et al. 2002, p. 6).

Consequently, an independent area of research—Grid economics—has been developed within recent years (Neumann et al. 2006, p. 206). Grid economics deals with the production, allocation, and consumption of Grid resources and tries to bridge the gap between the technological groundwork regarding Grid computing and business specifics. In this context, business models for Grid applications or market models for resource allocation are applied to Grid computing. Thus, Grid computing and a pay-per-use market, as one example of a business model, offer new economic possibilities, especially for outsourcing of IT in small- and medium-sized enterprises (SMEs) lacking the financial resources to afford investments into specific software licenses or infrastructures (Thanos et al. 2007, p. 6). Especially since collaboration within the business-to-business (B2B) sector has increased and several companies dispatch business processes and value chains in conjoined fashion, the Grid computing concept of virtual organizations and integration of resources across company boundaries proposes many new possibilities to businesses (Thanos et al. 2007, pp. 2-3). Recent research on Grid economics was published in Altmann and Veit (2007).

To conclude, the horizontal integration of resources is the main driving force behind Grid computing and offers various new possibilities especially to businesses. Yet, common standards are necessary in order to facilitate the interoperability and collaboration of virtual organizations. As the concept of virtual organizations is fundamental to pervasive Grid computing, a closer look will be taken at the scope of Grid computing and its classification.

2.1.2 Grid Classification

According to their perspective or purpose, Grid computing solutions can be classified differently. Krauter et al. (2002) view Grid computing solutions from a rather technical perspective and propose the categories computational, data, and service Grids. Joseph et al. (2004; see Figure 19) define a similar scale as "increasing IT complexity" (Infrastructure Optimization, Computing Grid, Data Grid, Service Grid, Virtualized Applications) and add a second dimension of "increasing organizational complexity"

(Enterprise Grid: Infra-Grid and Intra-Grid; Partner Grid: Extra-Grid and Inter-Grid). Yet, Plaszczak's and Wellner's (2006) approach will be followed which focuses on the organizational dimension in defining Departmental Grids, Enterprise Grids, Partner Grids, and Open Grids. This classification will be reduced to three steps according to the stages of collaboration and coordination: Intragrids, Intergrids, and open Grids.

Intragrids are Grid implementations within a single department (Departmental Grid) or organization (Enterprise Grid). They can yield considerable performance enhancements and cost-reductions, especially if departments are scattered around the globe (Thanos et al. 2007, p. 4). Servers and data centers can thus be integrated to increase the utilization rate. The organizational boundaries constitute a strong framework for controlling the offered resources since all resources stay behind the corporate firewall. Therefore, the security risk they exhibit is only minimal (Plaszczak and Wellner 2006, pp. 66-68). Within departments, sharing usually occurs between small user groups working closely together for which only simple rules and policies are necessary. Nevertheless, Grids spanning multiple departments of a company are in need for a system of usage policies as demand might exceed supply in peak times. However, the quantity of available resources is limited. The high level of control facilitates the enforcement of claims when being unsatisfied (Eymann et al. 2008, p. 13).

Intergrids consist of two or more Intragrids to collaborate in one common project, similar to business-to-business networks or VOs, and go beyond the corporate firewall (Plaszczak and Wellner 2006, p. 69). Thus, across organizational boundaries, the coordination in Intergrids depends on specific security or reputation mechanisms and service-level or framework agreements (Eymann et al. 2008, p. 11; Foster et al. 2002a, p. 40) as the level of control decreases. Intergrids are challenging to implement as security issues as well as organizational and psychological factors complicate their deployment. Therefore, participants are very careful about making their resources available (Plaszczak and Wellner 2006, p. 69). Within the respective contractual framework, Intergrids enable guaranteed levels of quality of service (QoS) (Hwang and Park 2007, p. 18), but the number of shared resources is still limited to the environment of business partners.

Open Grids will usually not be based on one single project. Rather all interested parties are able to share their resources within a pervasive Grid market, a platform for worldwide resource sharing (Plaszczak and Wellner 2006, pp. 70-71). Resources will consequently be shared within and beyond organizational boundaries. Yet, only a low level of control exists. The platform will be governed by decentralized market mechanisms, as no central institution for regulating the market will be present. Decentralized reputation systems therefore become more important (Eymann et al. 2008, pp. 17-19). Similar to the Internet today (Weishäupl and Schikuta 2004, p. 599), existing Intra- and Intergrids might form one global Grid in the future. Through access and usage transparency, users might resort to Grid resources without being aware of the respective complexity (Plaszczak and Wellner 2006, p. 71).

Although proprietary solutions might be possible within Intragrids and partially in Intergrids, the use of open standards and protocols is important in order to ensure scalability, interoperability and a close integration with existing systems (Plaszczak and Wellner 2006, p. 69). The more Grid solutions expand into open platforms, the more decentralization and market mechanisms for regulating resource sharing become necessary.

Technological maturity is an important factor for the future of a technology respectively innovation but cannot promote a technology separately (Thanos et al. 2007, p. 13). Therefore, a closer look will be taken at the market structure as well as the attitudes and characteristics of the respective market actors from a theoretical perspective in order to apply these findings to Grid computing subsequently. I will focus on Intragrids and open Grids in the following as mostly Intragrids are being deployed at the moment (see Ch. 2.3) and the findings will be later transferred to open Grids (see Ch. 5).

2.2 Market Structure and Characteristics

2.2.1 Heuß' Model of Market Phases

As the approach of the Harvard School (Industrial Organization in the narrower sense) and the concept of contestable markets limited their analysis on price determination that only persist under specific market conditions (Oberender and Väth 1989, p. 17), Heuß (1965) focused on additional parameters, susceptible by the entrepreneur. His general market theory centered the entrepreneur in the chronological development of market phases and, thus, forms part of the Austrian School of economics.

Indeed, Heuß' theory of market phases was eclipsed by the development of the "new industrial economics" (Erlei 1998, p. 2) which is why most of the following descriptions are based on Heuß (1965). Moreover, a shortening of market phases can be noticed in the field of digital goods (Fichert 2002, p. 4; Zimmerlich and Aufderheide 2004, p. 7). Yet, Heuß' fruitful elaborations of the attributes of market participants will yield interesting details in order to distinguish and to analyze the Grid computing environment. In a later stage of research, Heuß' model could also be used in order to define competition policies (Zimmerlich and Aufderheide 2004) demanded by Neumann et al. (2006), especially, since patents and legal policies can be deployed for prolonging a company's monopoly (Oberender and Väth 1989, p. 20). In this research, though, the model will only be used to obtain better insights into the structure of the Grid market, its actors, and their behavior.

The foundation for Heuß' general market theory was the analysis of individuals acting in a market and their mutual relations (Heuß 1965; Ch. 2). He concludes that different types of entrepreneurs exist that utilize the available parameters in the market differently. In addition to Schumpeter's (1952) concept, Heuß exemplified four different entrepreneurial types (Figure 2-1) in order to analyze the market processes subsequently.

On the one hand, the category of the progressive type spontaneously reacts to changes in the marketplace with innovative ideas and products and is thereby willing to take on the additional risks of such a structured market. *Pioneering entrepreneurs* therefore interpret parameters as products, costs or demand as manageable and shapeable. Their actions are thus based on spontaneity and intuition. The spontaneously *imitating entrepreneur* in turn imitates the product or service of the pioneering competitor and enters the market himself (Heuß 1965, pp. 8-9).

On the other hand, the conservative type only reacts defensively to external pressures and adjusts to the changing conditions of the market. Whereas the *reactive entrepreneur* only takes on new methods and ideas after a notable amount of pressure by his contestants, the *immobile entrepreneur* can only survive under stationary conditions and therefore calls for all possible interventions that will preserve these conditions (Heuß 1965, p. 10).

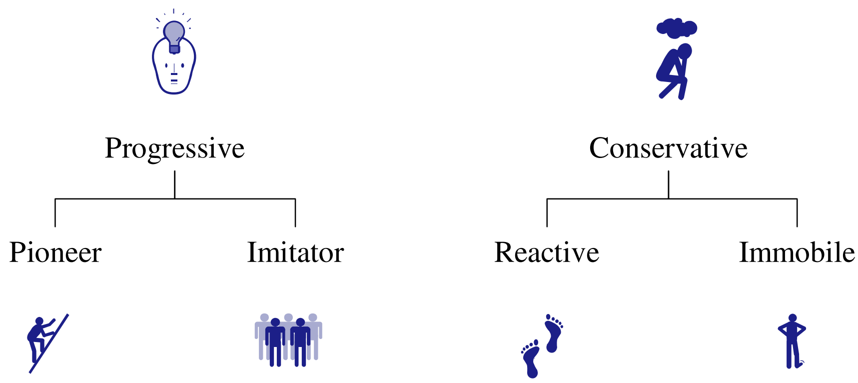

Figure 2-1. Heuß' classification of entrepreneurs (Source: Author, based on (Heuß 1965, p. 10))

Nevertheless, this taxonomy is not rigid in itself. The pioneering entrepreneur can easily turn into an immobile businessperson, as his assertiveness is key to success in the very first phases of a market, but can detain him from adapting to important changes within his environment at a later stage. Accordingly, a similar case exists between the imitating entrepreneur and his reactive counterpart. As it takes particular effort to enter a market, the entrant will soon loose a considerable amount of his energy after reaching a targeted position and will rather react to external pressures. However, the distinction between these two types of entrepreneurs is blurry.

Yet, in a traditional market, a product is regarded as given with a certain demand and supply. This market definition does not allow an examination of the aforementioned entrepreneurial types for whom all parameters as product, demand, costs, etc. are susceptible. The market only reflects a certain type of entrepreneur being active in a certain market phase. Heuß shows—based on the volume of production—that the market of perfect competition is only one of four possible market phases (Figure 2-2).

Nevertheless, the delineation of markets remains being complicated. According to the problem being analyzed, the delimitation has to be carried out on a case-by-case basis (Heuß 1965, pp. 23-24). A possible criterion is the interdependence of price. Companies are thought to be part of the same market if a participant's change in price affects the price policy of another market actor. However, this criterion is not applicable in the case of perfect competition.

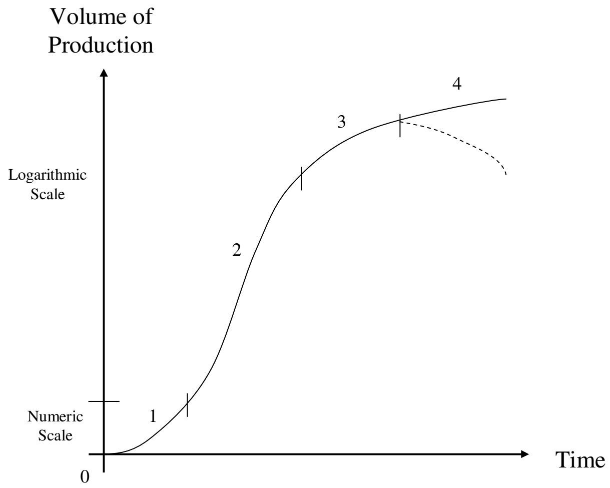

Figure 2-2. Heuß' market phases according to volume of production

1 – Experimental Phase, 2 – Expansion Phase, 3 – Maturation Phase, 4 – Stagnation and Degeneration Phase (Source: Author, based on (Heuß 1965, p. 15); translation from German)

Experimental Phase. In the experimental phase, no market in the original sense of the word yet exists, as the product still has to be developed. Heuß therefore constitutes two different phases of product development: one being the invention of a product, the second being the further enhancement for manufacturing. In turn, the manufacturing usually requires a broad set of additional inventions. Yet, the chances of success of a new invention can only be measured by subjective estimation, as the invention in itself is rather individual. Therefore, the realization or implementation of an invention is also based on intuition and belief.

The economic experimental phase, however, starts after the challenges of manufacturing have been resolved. In this phase, the key components are the creation of demand, the diminution of mistrust and skepticism and, subsequently, the persuasion of every possible consumer. As uncertainty and a high volume of risks coin the creation of demand, only pioneering entrepreneurs will be part of this early stage of a market (Heuß 1965, pp. 26-40).

Expansion Phase. In the expansion phase, the demand curve is rather influenced by the speed of the diffusion of the product than a periodic consumption. Income or price are in this phase only minor determining factors until the limit of the market will be reached which in turn constitutes the end of the expansion phase. The demand creation in this phase can instead be seen as a self-governed process. However, additional endeavors have to be undertaken in order to enter new markets and increase the demand for the product. Consequently, the initiative and assertiveness of the respective entrepreneurs is key to the expansion of the product.

In contrast to the creation of product and demand as main challenges in the experimental phase, a viable demand and a valuable supply determine the expansion phase. Improvements of quality and handling as well as enhancements of the product's features take place to improve the applicability of the recently entered markets. Similarly, rationalizations and cost reductions occur because of the process of experiences that then lead to major price reductions (Heuß 1965, pp. 41-62). Specific parameters that the entrepreneurs can influence and deploy in this stage are product, demand, costs, and price (Oberender 1973, p. 29).

Maturation Phase. In the maturation phase, production slows down and a small fraction of consumers remains that are indifferent towards the product due to objection or neglect. Therefore, new fields of application do not arise anymore and only product differentiations take place. This, in turn, leads to competition of the differentiated product with already existing products; but still new demand can be created. Yet, the more differentiation takes place, the stronger they converge to quasi-homogeneous goods with strong competition amongst one another until only small or no new demand can be generated. For this reason, oligopolies and monopolies in this classical market structure cannot be eliminated naturally and control the market (Heuß 1965, pp. 62-84). As the market moves on and becomes more transparent to the market actors, the number of available parameters decreases. Thus, in the maturation phase only price and quality of the product constitute changeable parameters (Oberender 1973, p. 29). Supply, demand, and product become fixed parameters.

Stagnation and Degeneration Phase. External pressures onto the market determine this particular phase. As enhancements in the production process become smaller and underperform the general economic development, labor costs and thus production costs will rise because of the increasing economic wage level. The market will shrink in total, though absolute growth for certain entrepreneurs is possible, as some of their contestants will leave the market (Heuß 1965, pp. 85-104). The only available parameter to the entrepreneurs is the price (Oberender 1973, p. 29).

In the degeneration phase, the introduction of highly innovative products will change the market structure as far as eliminating the obsolete products from their original market. However, the attitude of the involved entrepreneurs determines the date of the respective market. If rather innovative and proactive businesspeople are engaged in this market, it is possible that they will create a new market for these products and the degeneration phase can thus be overcome.

2.2.2 Diffusion of Innovation Theory

Diffusion theory, on the other hand, combines several different theories from behavioral sciences to marketing (Robertson and Gatignon 1986, p. 1), from research on information technology (IT) implementation to research on organizational behavior (Kwon and Zmud 1987, p. 227; Premkumar et al. 1997, p. 108), and includes theoretical and empirical findings from various backgrounds (Rogers 2003; Tornatzky and Klein 1982). It therefore serves as a useful reference discipline since innovation diffusion theory constitutes a very popular element of IT research (Allen 2000, pp. 210-211).

A general approach from diffusion theory to define the stages of a market or—more specifically—the stages of the diffusion of an innovation was mainly developed by Rogers (2003). "An innovation is any idea, practice or object that is perceived as new *by the adopter*" (Fichman 1992). The accumulated dispersion of a technology is generally thought to follow an S-shaped curve (Figure 2-3), similar to Heuß' general examinations of a single market. Regarding the additional growth of adopters, a bell-shaped curve under a normal distribution represents the diffusion process over time. Though, Rogers in contrast defined five different categories of so-called adopters using an innovation for the first time: innovators, early adopters, early majority, late majority, and laggards (Rogers 2003; see Ch. 7). The following description is mainly based on Rogers' classical diffusion theory, as it became the foundation for diffusion research.

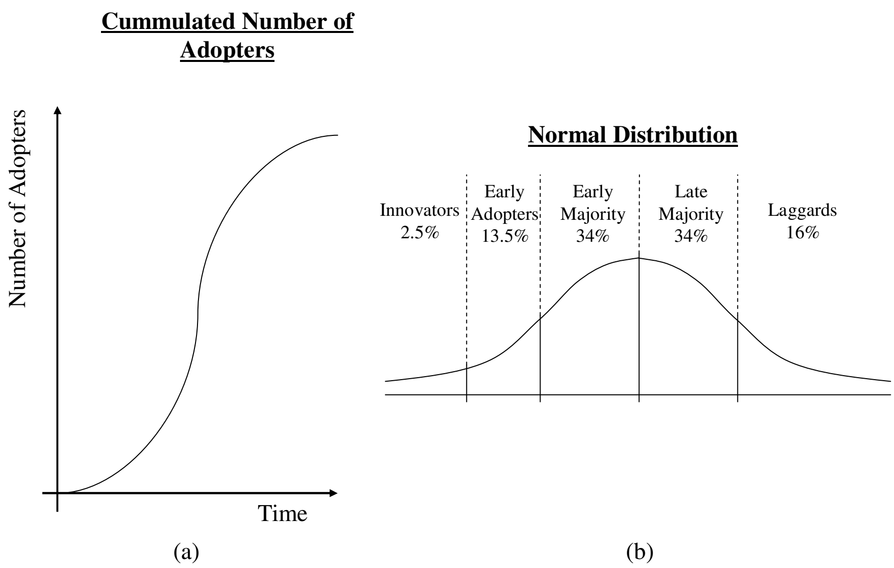

Figure 2-3. (a) Accumulated dispersion of an innovation , (b) Diffusion process over time follows a bell-shaped curve under the normal distribution (Source: Author, based on (Rogers 2003, pp. 273, 281))

Innovators. Innovators can be described as being daring, risk-loving, cosmopolite, as well as technically interested. They have the ability to back their ventures with adequate financial resources in case an innovation turns out to be unfavorable. Thus, an innovator also has to be capable of coping with setbacks, poorly conceived documentation and functionality (Moore 1999, p. 31). Although local peers do usually not respect him, the innovator has an important role in selecting promising innovations to introduce into the respective system (Rogers 2003, pp. 282-283).

Early Adopters. In contrast to innovators, early adopters are rather integrated into the underlying system. Especially interested adopters resort to their opinion leadership for obtaining information as well as good or bad case practice about the technology. Moreover, especially change agents reach out for early adopters in order to speed up the diffusion process. As a role model, they have the ability to reduce uncertainty about innovations and to approve the technology in adopting it. They are key for reaching a critical mass (Rogers 2003, p. 283).

Early Majority. A strong interpersonal connection exists between the early adopters and the early majority. In fact, the latter constitutes an important link within the whole system or market. Yet, they lack opinion leadership. One third of all market members fall within this category adopting an innovation before the average member. They consider the adoption carefully and rather follow their peers deliberately (Rogers 2003, pp. 283-284).

Late Majority. Similar to the early majority, the late majority consists of one third of possible market participants. As was already described in Heuß' theory, the pressure on conservative entrepreneurs rises, thus also forcing them to adopt the new technology or product. The late majority can be described as being fairly skeptical and cautious. Therefore, most of an innovation's uncertainty has to be removed (Rogers 2003, p. 284).

Laggards. Furthermore, laggards represent the last category of possible technology adopters. They are rather detached from their peers and follow traditional values. Moreover, laggards are suspicious of any innovation as well as change agent urging them to adopt. Additionally, they only own a small amount of resources, which denotes that an innovation has to function properly without any uncertainty (Rogers 2003, pp. 284-285).

Change Agents. In addition to the opinion leaders respectively early adopters, another important role in the innovation diffusion process inherit the change agents as they can influence and consequently speed up the process (Fichman 2000). Change agents can be consultants or salespeople (Rogers 2003, p. 368), have a “high degree of expertise” and are part of innovation and client networks. Since having a different language and vocabulary, communication could be a barrier in direct communication with clients. They also have to deal with information overload, since being part of the innovation network in which a lot of irrelevant information is transmitted. Thus, choosing the right information for each client is important.

Not only is the client contact important in measuring the success of change agents, the phases of the innovation cycle also play a major role. At the beginning, the agent’s effort mostly equals the rate of adoption. After a critical mass is reached and the opinion leaders adopt the innovation, change agents become less important in creating awareness for the new technology (Rogers 2003, p. 374) and the opinion leaders further guide the process of opinion formation.

In addition to Heuß’ market theory, similar and additional information about the theoretical market phases and characteristics of the market actors could be found in the classical diffusion theory. In the following, this specific information will be applied in order to analyze the existing Grid market and its structure.

2.3 Grid Market Structure

2.3.1 Market Phases of Grid Computing

Although Grid computing became part of a hype in the research and commercial sphere, it is now crossing the disillusionment phase and will need another two to five years in order to reach maturity; a similar development as SOA and Web Services (Fenn and Linden 2005; Figure 2). In the following, the predictions from business and research concerning the commercial diffusion and deployment of Grid solutions will be examined more closely. The findings from the previous chapter will serve as theoretical foundation. Moreover, I will examine the diffusion process and its determinants that facilitate or constrain the diffusion of Grid computing. Consequently, the key issues will be worked out according to the actual market structure and theoretical propositions will be derived.

Commercial Predictions. Several commercial Grid reports and market analysis are available: the 451 Group Grid Adoption Research Service (451 Group 2006), the Oracle / Quocirca Grid Index (Quocirca 2006), Gartner Research (Chuba and Claunch 2006; Fenn and Linden 2005), or the Global Grid Computing Reports 2002 and 2007 by Grid Technology Partners (2002), only to name a few. Nevertheless, these commercial reports, indexes, and research studies tend to be biased, as the corresponding companies are mostly involved in the Grid computing business themselves. These forecasts, therefore, have to be taken carefully (Forge and Blackman 2006, p. 24). In general, forecasts on the Grid market development are mainly industry driven which is why serious research on this topic is hard to attain. Nevertheless, an overview of the state-of-the-art in Grid research can be found in Altmann and Routzounis (2006).

Early adopters of Grid computing can especially be found in the finance and banking, pharmaceutical, or manufacturing sectors (e.g. automotive, aerospace) (451 Group 2006; Forge and Blackman 2006, pp. 6, 21) as they either require a great amount of computing power for computing simulations or the involved functions and resources are scattered geographically and in different administrative domains.

Conclusions from Research and Theory. As of 2004, the adoption of Grid computing was in the “very first phase” (Abbas 2004, Ch. 19). Since then, the situation has not fundamentally changed, although commercial research institutions predict Grid computing to be in the “early adopter”-stage: The use of Grid computing is still limited, and especially SMEs do not consider the use of Grid technologies (Schikuta et al. 2005, p. 4). Therefore, Altmann et al. (2007, p. 30) call for a clear analysis of value chains or cost models and demand incentives as well as concrete business models.

From Heuß' and Rogers' models it can be concluded that the market for enterprise Grids is already in the stage of expansion respectively early adoption. However, the technological standards and security issues are currently not that mature (Plaszczak and Wellner 2006, p. 177). Therefore, it is doubtable if a market for open Grids already exists.

Yet, tools with open-end support are being developed for creating a pervasive Grid infrastructure. Still, experienced and dedicated people are necessary to implement Grid technologies which is why more practical and simpler applications and tools are needed, especially in the enterprise sector (Parashar and Lee 2005, pp. 481-482). This might be a reason why many companies focus on supporting rather rudimentary Grid capabilities like cycle scavenging and data storage today. The concept of virtual organizations is yet not included in on-demand offerings (Plaszczak and Wellner 2006, p. 87). As a general rule, Abbas (2004, pp. 25-27) predicts an integration of servers first and consecutively of applications, data centers, staff, and similar resources. This seems reasonable as less people involved in the decision process will ease and speed up the process (Rogers 2003, p. 221).

Although enterprise Grid computing has reached the early adopters-stage, the early majority has not been reached yet (BEinGRID 2008). Moore (1999) calls this phenomenon a "chasm" in innovation diffusion, the so-called gap between the early adopters and the early majority. Still, past research did not reveal any clues for the existence of such a gap between adopter categories (Rogers 2003, p. 282). Following Heuß (1965, p. 42), the expansion of demand to reach a critical mass (Rogers 2003, p. 283) is rather bound to additional efforts to create demand for the innovation and to conquer new markets. Depending on the speed of diffusion, this process can be rather lengthy and might be comparable to Moore's gap between early adopters and early majority. Still, his elaborations about marketing possibilities in this context seem quite appealing in order to derive advice for practitioners and marketing campaigns.

In addition, commercial as well as scientific research on adoption and diffusion tend to show a pro-innovation bias (Allen 2000, pp. 212-213; Rogers 2003) assuming that over time an innovation will be adopted because of its positive features. Foster et al. (2002a, p. 38) for example predicted Grid computing to enhance the Internet tremendously. Especially the aforementioned commercial reports and presentations glorify Grid technologies in order to create awareness amongst enterprises and to obtain new customers.

Nonetheless, as resource-sharing is very important in Grid computing, corporate cultures, the organizational member's individual perception of security threats or even legal challenges (e.g. copyrights, licenses, ownership definition) may hinder the adoption of Grid computing (Parashar and Lee 2005, p. 482). Thus, not only technical issues have to be resolved in order to enhance Grid computing and to establish a market for open Grid resources. In addition, perceived challenges and concerns have to be taken into account.

2.3.2 Diffusion Process and its Determinants

As outlined before, the diffusion of enterprise Grids is bound to a complicated process of creating demand for Grid computing. Especially, engrained attitudes towards management practice and business processes hinder the deployment of new techniques (Carr 2005, p. 71). As diffusion theory also analyzes the determinants of facilitating or deterring innovation adoption (Chwelos et al. 2001, p. 305), I will take a closer look at the determinants and factors that influence the corporate attitude on innovations and, thus, the intention to adopt the new technology. Although Chwelos et al. further argue that most of the research regarding technological factors has focused on "individual-level adoption", a review of literature on IT diffusion also reveals that a similar amount of research was spent on innovation with high-knowledge burdens in an organizational context (Fichman 1992). For this reason, I will specifically refer to this aspect of innovation diffusion theory in order to outline a few possible determinants of the adoption of Intragrids.

Diffusion Process. The process of diffusion of innovations is usually structured into three stages: initiation, adoption, and implementation (Thompson 1976). In contrast, Kwon and Zmud (1987) find that the IS implementation process within a company should rather be analyzed as a six-stages process (initiation, adoption, adaptation, acceptance, use, incorporation). Certainly, a global perspective of influential factors during the process of implementing IT innovations is important. However, as the adoption of Grid technologies is in the focus of this research, this study focuses rather the initiation of the process respectively the final adoption decision with its determining factors.

Determinants of Innovation Adoption. As the innovation diffusion research was applied to several areas of research, I will resort to fields that are closely related to Grid computing. As Grid computing relies on the interchange of data in order to exchange resources, diffusion research on EDI (Electronic Data Interchange) (e.g. Chwelos et al. 2001; Premkumar et al. 1997) is closely linked to determinants for the adoption of Grid technologies. Furthermore, Hwang and Park (2007) as well as Thanos et al. (2007) have taken first steps in presenting decision factors that influence the adoption of Grid computing within business environments. Maqueira and Bruque (2006) even presented a first adoption model for Grid computing. But as the corresponding fundamentals are based on an unpublished work and the model resorts to Premkumar's et al. (1997) model, I will rather exert the latter. Furthermore, Rogers' model is usually used as classical theory for forecasting the development of the diffusion of technologies (Moore 1999, p. 11). Yet, one has to be careful in applying classical diffusion theory to new contexts (Fichman 1992). According to the context, determinants of diffusion and adoption therefore have to be selected appropriately.

Technological. From the model of market phases and the adopter categories, it can be concluded that technological factors are driving an innovation especially in the first phases of a market. As can be derived from Rogers' model (Rogers 2003; Ch. 6), the five attributes relative advantage (being better than the previous technology), compatibility (to conform to beliefs, experiences, and needs), complexity (degree of difficulty to understand), trialability (possibility of testing prior to adoption), and observability (visibility of results) explain most of the variance in the rate of adoption. However, research has only found three out of 25 differing variables to be affecting adoption (Tornatzky and Klein 1982), namely relative advantage, compatibility, and complexity. This is supported within Grid environments as Grid computing has to be able to deliver increased business value (Joseph et al. 2004, p. 638). Yet, Moore and Benbasat (1991) presented an instrument for measuring the adopter's perception of an innovation. Thus, Rogers' observability was found to be separable into result demonstrability and visibility (being visible to the adopter, e.g. hardware). They further described the factors ease of use (use is "free of physical and mental effort" (Davis 1989, p. 82)), image (enhancement of individuals' social status), and voluntariness (degree of being free to choose adoption) to influence an adopter. Kleinaltenkamp (1995, p. 2362) also predicted product standardization to speed up the diffusion, as new competitors will enter the market because their knowledge about the standard solution increases. This development can also be seen in Heuß' market development. The more transparent a market becomes, the more knowledge will the entrepreneurs have about their competitors and their products, and imitate them. Moreover, Hwang and Park (2007) observed the ease in implementation as being an influential determinant of Grid computing adoption. Table 2-1 summarizes the described technological factors.

Table 2-1. Technological factors

Technological	
– Relative Advantage – Compatibility – Complexity	(Rogers 2003; Ch. 6; Tornatzky and Klein 1982)
– Observability	(Rogers 2003)
• Result demonstrability • Visibility	(Moore and Benbasat 1991)
– Ease of use	(Davis 1989)
– Image – Voluntariness	(Moore and Benbasat 1991)
– Product standardization	(Kleinaltenkamp 1995)
– Ease in implementation	(Hwang and Park 2007)

Organizational. Yet, organizational and environmental factors also affect the organizational intention to adopt an innovation. Apart from top management support, size was also found to be a predictor variable for innovation diffusion and adoption (Chwelos et al. 2001, pp. 305-306; Premkumar et al. 1997, p. 117). Thus, financial or similar resources for the adoption depend on top management commitment. Additionally, the greater a company is the more financial resources it could deploy for the utilization of new technologies. However, as research on organizational factors has found weak or contradictory results, Fichman (1992, pp. 15-16) suggested to include absorptive capacity ("ability to exploit external knowledge" (Cohen and Levinthal 1990, p. 128)) or the expectation of adopters whether critical mass will be reached. He also proposed—among others—IT group characteristics, organizational processes or characteristics being able to influence the intention to adopt. Table 2-2 summarizes the described organizational factors.

Table 2-2. Organizational factors

Organizational	
– Top management support	(Chwelos et al. 2001; Premkumar et al. 1997)
– Size	
– Absorptive capacity	
– Expectation whether critical mass will be reached	(Fichman 1992)
– IT group characteristics	
– Organizational processes or characteristics	

Environmental. Regarding environmental factors, Fichman (1992) further proposed to measure the number of knowledge-barrier reducing institutions and competitive pressure as influencing variables. Competitive pressure was also found to be a predictor variable in the context of EDI (Chwelos et al. 2001, p. 315; Premkumar et al. 1997, pp. 115-116). Furthermore, in the context of Grid computing, network externalities and issues related to information asymmetry, risk, and unpredictability (Thanos et al. 2007, pp. 12-13) were regarded as having an important influence on the willingness to participate in a Grid environment. Thus, benefits of the technology increase with an increasing number of participants. Additionally, only incomplete information is available about other participants, which can hinder the adoption decision. In addition, the uncertainty and complexity of a company's environment (Hwang and Park 2007, p.

24) as well as interorganizational relationships, including power, dependence, trust, or climate, also pose challenges concerning the intention to adopt a technological innovation (Bensaou and Venkatraman 1996; Cavaye 1996; Clemons and Row 1993; Premkumar and Ramamurthy 1995; Reekers and Smithson 1996). Table 2-3 summarizes the described environmental factors.

Table 2-3. Environmental factors

Environmental	
– Knowledge barrier-reducing institutions	(Fichman 1992)
– Competitive pressure	(Chwelos et al. 2001; Fichman 1992; Premkumar et al. 1997)
– Network externalities	
– Information asymmetry, risk, and unpredictability	(Thanos et al. 2007)
– Uncertainty – Complexity	(Hwang and Park 2007)
– Inter-organizational relationships • Power • Dependence • Trust • Climate	(Bensaou and Venkatraman 1996; Cavaye 1996; Clemons and Row 1993; Premkumar and Ramamurthy 1995; Reekers and Smithson 1996)

2.3.3 Key Issues in Grid Computing

As can be concluded from the previous section, technological and (perceived) security issues pose an important influential factor in the context of Grid computing and the hindrance of adoption in commercial environments.

In addition, a necessary requirement for the commercialization of Grid computing is also the necessity to express the value of its resources (Buyya et al. 2005, p. 699) and the corresponding costs. Therefore, cost models and incentives—inter alia—need to be examined (Altmann et al. 2007, p. 30). Since the Total Cost of Ownership-model of the Gartner group has gained much attention over the past years (Wild and

Herges 2000, p. 4), this cost model will be examined in the context of Grid computing.

Therefore, the economic challenges (in terms of Total Cost of Ownership and Quality of Service) and the perceived security issues in the Grid computing environment will be examined in more detail and theoretical propositions will be derived consequently.

2.3.3.1 Total Cost of Ownership and Quality of Service

Management accounting "measures, analyzes, and reports financial and nonfinancial information that helps managers make decisions to fulfill the goals of an organization" (Horngren et al. 2006, p. 2). On the other hand, cost accounting is a function of management accounting in providing the necessary information related to "acquiring or using resources in an organization" (Horngren et al. 2006, p. 2). Thus, several key success factors determine a company's ability to deliver increasing performance levels: cost and efficiency, quality, time, and innovation.

However, managers can only decide accurately based on sound information. Therefore, a thorough cost accumulation is necessary. Regarding IT-related costs, the technological change from mainframes to client-server-architectures induced the necessity for changes in management accounting. Although direct costs (e.g. software or hardware costs, costs for employee training, or maintenance costs) can be retrieved from the accounting systems, indirect costs (e.g. costs induced through productivity losses, downtimes, or private usage) can amount to 55% of all total costs (Gadatsch and Mayer 2006, pp. 90-91) and were not represented in any management system in the past.

In 1987, the Gartner group, therefore, presented their first Total Cost of Ownership concept (TCO) which is based on a lifecycle examination of IT assets (Treber et al. 2004, p. 12) in order to make indirect costs more transparent (David et al. 2002, pp. 101-102; Gadatsch and Mayer 2006, p. 91). A specific IT-based chart of accounts lists all direct and indirect costs more transparent than it would be possible with traditional cost accounting systems. With this more specific cost information, it was possible to derive better recommendations for further and more accurate cost savings. Originally developed for evaluating the costs of personal computers, the concept was gradually deployed to further contexts (Wild and Herges 2000, p. 3).

Although the Gartner concept was originally developed for presenting the drastic shifts from direct to indirect costs and did not constitute a controlling tool literally, it was gradually enhanced to become a tool for cost measurement and cost management (Treber et al. 2004, p. 20). Although the TCO concept had a fundamental role within the cost accounting field as it constituted the first IT-specific cost model, it was strongly criticized for its cost orientation without considering the benefits-perspective. This, however, led to the development of the first IT-specific total value concept (Wild and Herges 2000, pp. 29-30) and further concepts trying to combine the TCO cost perspective with a value-based return-on-investment (ROI) perspective. However, TCO is not to be seen as an antipode to ROI, but as a necessary requirement to delineate costs for evaluating investments (Treber et al. 2004, p. 47).

Thus, as several TCO concepts and enhancements exist driven by commercial interests of the respective consultancy, no common understanding and standard has yet been developed (Treber et al. 2004, p. 40). Therefore, I will consider TCO as a tool for mapping and managing IT costs in the following. A value-based evaluation has to be subject of further controlling tools. A comprehensive overview of the TCO topic, its development, the enhancements, and the delineation of different TCO concepts is given in Treber et al. (2004).

TCO and Grid Computing. The arising possibilities and a new flexibility that was introduced through distributed computing—in contrast to mainframes—led to an increasing complexity within IT infrastructures. Paradoxically, the total cost of ownership gradually increased (Sterritt 2005, p. 79; Treber et al. 2004, p. 15). However, competitive pressures within a company's environment constantly forces managers to reduce costs and increase efficiency. Therefore, server consolidation or outsourcing constitute potential cost savings (Abbas 2004, pp. 24-25). In this context, Grid computing is viewed to be a technology for horizontally integrating server architectures, which, thus, leads to increased utilization rates and reduced costs (Carr 2005).

Nevertheless, a service-oriented approach and the horizontal integration of hardware will lead to less accuracy in cost allocation. As many applications and processes will resort to one single hardware infrastructure, the accruing costs will not be directly mappable to corresponding benefits with existing cost allocation systems. Therefore, Göhner et al. (2006) developed a first approach for an activity-based costing within the Grid computing sphere.

Although several systems for trading resources have been built so far (including "commodity-market models, posted price models, bargaining models, tendering, or contract-net models, auction models, bid-based proportional resource sharing models, cooperative bartering models, as well as monopoly and oligopoly" (Buyya et al. 2005, p. 699)), there is still a huge need for evaluating Grid resources. As the TCO concept was originally developed for distributed systems, the question arises if TCO are also applicable within the scope of Grid computing. Therefore, the following propositions were derived from the aforementioned elaborations:

Proposition 1: TCO concepts are deployed since being important for the evaluation of the profitability of IT investments

Proposition 2: TCO concepts in their actual form are not sufficient for the deployment in Grid computing

Proposition 3: Grid computing can be used for reducing TCO

TCO can unfavorably affect service levels (David et al. 2002, p. 102). Thus, for example, the reduction of costs might reduce the quality at the same time as the number of staff might be reduced. Therefore, the challenge arises to reduce costs and keep the offered service on the same level or even increase service at the same time. As a high QoS is necessary for a "satisfactory user-experience" (Joseph et al. 2004, p. 624), service level agreements are an important tool for customers being able to judge the Quality of Service within a Grid environment (McKee et al. 2007, p. 59). Research proposes that Grid computing can increase the Quality of Service. Therefore:

Proposition 4: Grid computing can be used to increase the Quality of Service (QoS)

2.3.3.2 Security Issues

Furthermore, for a successful adoption of Grid technologies, security services play a decisive role amongst an adequate infrastructure, applications, and portals (Joseph and Fellenstein 2004, p. 30). Especially when intending to reduce costs through outsourcing, one has to deal with security and trust issues in Grid environments (Abbas 2004, pp. 57, 273-274). In fact, these trust issues have not been solved or eliminated yet, especially in "open and shared computing environment[s]" (Hwang and Park 2007, p. 26) as for example virtual organizations.

However, from our perspective, the general term security comprises both hard and soft security aspects (Rasmusson and Jansson 1996). Hard security protections mostly cover technical solutions for keeping malicious parties out of a system (e.g. firewalls, authentication, etc.). Once in the system, uncertainties and incomplete information arise. Therefore, soft security mechanisms as trust (the willingness of an individual to rely on another party (Jøsang et al. 2007, p. 4)) and reputation ("what is generally said or believed about a person's or thing's character or standing" (Jøsang et al. 2007, p. 5)) become necessary. More detailed definitions and delineations of the aforementioned terms can be found in Appendix B. Yet, both hard and soft security issues challenge the Grid environment. Hence:

> Proposition 5: Security aspects are important for companies' internal and external usage of Grid computing

Thus, security is one of the most important determinants for the adoption and diffusion of Grid technologies, with which standard bodies and vendors particularly deal with (Abbas 2004, p. 57). Because of the Grid's nature to deal with geographically distributed resources from divergent security domains, security mechanisms are already build into the resource layer of the Grid architecture. Nevertheless, the challenges to secure a Grid environment become even more complicated since varied stakeholder interests—e.g. consumers, service providers, resource owners—influence the requirements for Grids.

Plaszczak and Wellner (2006, p. 154) show that the necessary technical security tools are already available. Humphrey et al. (2005) also provide a general overview of the different advancements concerning trust-, policy as well as authorization-management in Grid environments. Though, securing very sensitive data in the Grid remains being very difficult (Abbas 2004, p. 274) as the modeling of security methods for sensitive data is still at its very beginning (Plaszczak and Wellner 2006, pp. 154-155).

Intragrids do not raise special security risks (Eymann et al. 2008; Plaszczak and Wellner 2006, p. 189) as they are situated within company boundaries and a strong control exists. Inter- and open Grids have to be assembled carefully (Plaszczak and Wellner 2006, p. 189). Yet, today's security mechanisms used inherit similar or even worse security concerns. Nevertheless, security concerns are among the most important reasons that hinder the deployment of Grid solutions (Plaszczak and Wellner 2006, p. 177); and most of these concerns are rather based on belief than on actual arguments. As security in Grid environments are of complex nature:

Proposition 6: Security concerns hinder the deployment of externally sourced IT services

Grid computing is mostly seen as enabler for other applications and benefits since being suited on architectural level and offering needed technical standards. Therefore, no customer need in itself exists for Grid computing but for the services that can be created with Grid technologies (Plaszczak and Wellner 2006, p. 197; Sainio and Porras 2006). In addition, the standardization of services can reduce information asymmetry in open markets (Eymann et al. 2008, pp. 8-9). Hence:

Proposition 7: Grid computing is more suitable for standardized services than individual services

In the previously mentioned dynamic environment of virtual organizations, specific security challenges emerge (Foster et al. 1998; Welch et al. 2003). Humphrey et al. (2005) group these challenges into four distinct categories: naming and authentication; secure communication; trust, policy, and authorization; as well as enforcement of access control. In addition, theoretical and technical steps have been taken to introduce trust in uncertain environments. For example, Cahill et al. (2003) introduce the human notion of trust in order to derive a decentralized security management approach. Moreover, Brinkløv and Sharp (2007) describe a first approach of technically introducing behavioral trust into open Grid systems. Yet, as explained before, these approaches mainly comprise technological solutions. Examining corporate attitudes regarding trust and reputation in order to obtain a better insight into the individuals' beliefs and fears towards soft security aspects will therefore be in the focus.

As trust between trading partners is important (Premkumar et al. 1997, p. 111), feedback rating respectively reputation systems (Jøsang et al. 2007; Resnick and Zeckhauser 2002) represent a possible solution for reducing uncertainty in online-auctions (Standifird 2002) and within uncertain environments as the Internet. Reputation systems especially offer the possibility to systematically distribute information on the past behavior of market actors (Resnick and Zeckhauser 2002). Within an open Grid market, we, therefore, propose that:

> Proposition 8: Feedback rating systems are important for the selection of IT service providers

As open systems rely on social control (Rasmusson and Jansson 1996), actors are welcome as long as they do not harm other participants. Therefore, the participants are responsible for providing the security themselves. However, there is no economic incentive to provide feedback on transactions and experiences. Nevertheless, more than half of the transactions' participants on eBay did provide feedback (Resnick and Zeckhauser 2002). I, therefore, propose:

> Proposition 9: No differences exist between passive and active usage of public feedback rating systems

2.3.3.3 Further Requirements for an open Grid market

In order to develop a platform for trading open Grid resources, further requirements become necessary, apart from cost models and security-issues. Firstly, standards play an important role in the use of information technology as they enable interoperability of applications and resources (Hofmann and Beaumont 2005, pp. 279-280). Still, standards represent a compromise between business interests, proprietary solutions, and technical possibilities.

Especially Foster and affiliated researchers have proposed that open standards are fundamental to the development of Grid computing (Foster 2002; Foster and Tuecke 2005, p. 33). Grid computing depends on the communication of different services of any party and thus is a key success factor in order to create interoperability between different systems and infrastructures. Therefore, only one agreed standard (e.g. OGSA) seems reasonable rather than just one middleware solution (Hwang and Park 2007, p. 26). As OGSA already incorporates Web services, it will be interesting to see which other standards companies use for internal and external data exchange and which of them is the most prevalent standard.

Furthermore, since Grid computing technologies offer the possibility of using diverse applications, a seamless integration of resources is necessary for the Grid user (Kwon et al. 2004, p. 48). In the context of e-business as well as fast moving and highly competitive markets, Kalakota and Robinson (2001, pp. 56-57, 143) view the integration of services and the underlying infrastructure as a key to success. Only a seamless integration of applications can therefore serve the customer efficiently and satisfyingly. Business-to-business (B2B) collaboration—which is one form of a virtual organization—also has a high demand of resource integration (Foster et al. 2002b, p. 7) as contemporary B2B-solutions are rather concerned with information sharing (Foster et al. 2001, p. 201).

Additionally, so-called "eUtilities" (Foster et al. 2002b, p. 6) recently emerged offering the possibility of integrating outsourced IT-services with in-house IT infrastructures. But the demand for business process integration and the integration of legacy systems poses a high burden especially on large companies (Kalakota and Robinson 2001, p. 144). Nevertheless, the goal for aggregating distributed resources remains a key objective (Parashar and Lee 2005, p. 481). Therefore:

Proposition 10: A high integration of Grid computing applications into existing implementations is important

Moreover, according to Kwon et al. (2004, p. 48), the details of the Grid computing infrastructure should be hidden from the user who is rather interested in the execution of applications and the final results. Therefore:

Proposition 11: External services should be accessed transparently

Table 2-4 gives a concise overview of all propositions.

Table 2-4. Overview of propositions

Propositions	
Proposition 1	TCO concepts are deployed since being important for the evaluation of the profitability of IT investments
Proposition 2	TCO concepts in their actual form are not sufficient for the deployment in Grid computing
Proposition 3	Grid computing can be used for reducing TCO
Proposition 4	Grid computing can be used to increase the Quality of Service (QoS)
Proposition 5	Security aspects are important for companies' internal and external usage of Grid computing
Proposition 6	Security concerns hinder the deployment of externally sourced IT services
Proposition 7	Grid computing is more suitable for standardized services than individual services
Proposition 8	Feedback rating systems are important for the selection of IT service providers
Proposition 9	No differences exist between passive and active usage of public feedback rating systems
Proposition 10	A high integration of Grid computing applications into existing implementations is important
Proposition 11	External services should be accessed transparently

3 Research Methodology

The Grid computing environment is hardly explored empirically concerning the aforementioned key challenges. The Chair of Information Systems at the University of Bayreuth therefore developed a lead questionnaire from the presented propositions. The aim of the conducted explorative study is to yield first insights into the existing Grid market regarding the aforementioned key challenges and the corporate attitudes towards Grid computing. Subsequently, hypotheses of possible determinants for the construction of an open Grid market platform will be derived. Therefore, the goal of the conducted research is generalizing to theory (Kerlinger 1976, pp. 8-10), not to any specific population.

3.1 Operationalization of Questionnaire

For each theoretically derived proposition from Ch. 2.3.3 two items were constructed in the questionnaire. A five point Likert scale ("strongly agree" to "strongly disagree") was used in order to measure the items. The response categories will be abridged with the following abbreviations: "SA" = strongly agree; "A" = agree; "N" = neutral; "D" = disagree; and "SD" = strongly disagree. In addition to the mentioned theoretical questions, further items and control variables were deemed desirable for collecting further information on the attitude towards Grid computing and its requirements. For a detailed description of all items, see Appendix D.2.

Firstly, the knowledge about Grid computing and a possible positive influence on the attitude induced by the usage of Grid technologies was surveyed with items d1a1 (I'm familiar with the idea of Grid computing) and d1a2 (Grid computing infrastructures are already being used in my enterprise). In fact, variables d1a1 and d1a2 were counted as control variables since only company representatives with prior knowledge of Grid computing could have answered the questionnaire assiduously. Furthermore, the use of Grid computing constitutes a possible pro-innovation bias that has to be controlled for.

In addition to the items regarding the propositions, the mentioned further requirements from Ch. 2.3.3.3 were translated into questionnaire items. Consequently, item d2e1 asked for the used standards in the respondent's company. The offered options for possible communication standards were SOA standards, Web Services, CORBA (Common Object Request Broker Architecture), individual XML (Extensible Markup Language) messages, EDI (Electronic Data Interchange), IDoc (Intermediate Document), Java Messages, Component-based messages, and others. Multiple options were selectable. The option others was set up as open text field.

Proposition 10 formed item d2e2 (A high integration of grid computing applications into existing implementations is important). Proposition 11 was measured through item d2e3 (External services should be accessed transparently).

As Grid computing was described as being a promising enhancement of the Internet and led to a hype in research, the perceived future of Grid computing within the IT sector and within one's business was measured with items d3a1 and d3a2 respectively.

A first demographic item was d3b1 asking for the sector in which a company is situated. A text field was offered to the respondents for answering this question. In addition, d3b2 measured the size of the company by asking for the number of employees. Six options were offered: 1-10, 11-50, 51-250, 251-500, 501-1000, >1000. Moreover, the respondents were asked for the department they work in (d3b3). The response was recordable in a parameter-free text field. Furthermore, three options were selectable for the role each company has within the Grid computing market (d3b4): IT-service provider, IT-service consumer, and IT-application provider. An additional text field offered the possibility to indicate a role that was not mentioned in the questionnaire. As companies can have several roles at the same time, multiple options were selectable. Furthermore, the country of origin was asked for with item d3b5.

3.2 Data Collection

In order to derive valuable results and apply them to open Grids, it is necessary to examine the attitude of companies and institutions that are already familiar with Grid computing. However, as it remains unclear which companies specifically use Grid computing already, existing research communities on Grid computing were chosen for the study.

As this explorative study is conducted as pre-study in order to derive in-depth insights and hypotheses, an online survey constituted an inexpensive and fast solution to consult the geographically distributed research communities.

Furthermore, since Grid solutions still need dedicated and experienced people for their deployment and usage (Parashar and Lee 2005, p. 481), it was assumed that participants in Grid communities are spokesmen of their company leading the research development in these companies and taking part in the important research communities on Grid computing. In turn, these company representatives act as proxy for their organization and its attitude towards Grid computing.

With the already described market structure and its broad variety of Grid networks, contacts within several research communities were collected. Starting at the beginning of October 2007, an e-mail was sent out to the coordinator of each community requesting them to support our study in filling in the online questionnaire and asking them to forward this request to all the partners of their research group. An overview of contacted research networks is given in Table 3-1. If an answer was retrieved from the coordinator with the confirmation that our request was forwarded or this fact could be elicited from the questionnaire answer sheets, the respective network was marked accordingly as being surveyed.

Table 3-1. Surveyed Grid computing research networks

Network	Surveyed
BEinGRID	
Activity 2	
BREIN	
D-Grid 2	
AeroGrid	
BauVOGrid	
BIS-Grid	
Biz2Grid	
D-Mon	
F&L-Grid	
Fin-Grid	
GDI-Grid	
InGrid	
MediGRID	
PartnerGrid	
ProGrid	
SuGI	
SORMA	
NextGrid	

Thirty-three answers were received. With 137 project partners in these networks, this constitutes a response rate of 24%. Excluding missing values in the data sets, the response rate decreases to 18%.

3.3 Data Preparation

After the collection, the data had to be prepared for the analysis. Thus, the final analysis only includes 24 responses due to missing values. This reduces the sample size significantly but will in turn facilitate the calculation of inter-item correlations, for example, for which an equal number of responses—without missing values—is needed. In addition, d1b2 was also excluded for the analysis, as two additional responses would have to be excluded although all other questions were answered. D1a1 served as control variable to exclude answers if the respondents were not familiar with Grid computing. This was not the case. Nevertheless, d1a1 was only used for the description of the sample characteristics.

Also, while describing and analyzing the data, percentages will be rounded to the nearest integer in order not to feign inappropriate accuracy (Ehrenberg 1976, pp. 58-59). Percentages, therefore, might not add up to 100% in each case.

The five-step Likert-scale, with which each item was measured, will be reduced to a three-step scale in the analysis. Thus, “strongly agree” and “agree” form the category of a positive answer (“+”); “disagree” and “strongly disagree” will be conflated to form the category of a negative answer (“-“). The category “neutral” (“o”) remains unaltered. Only within the examination of correlations, I will resort to the five-step scale in order to verify a linear tendency between two items. In all other cases, this level of detail is not necessary for our analysis.

Since the questionnaire did not offer a pre-defined structure for the respondents to record the industrial sector of their company, the responses were clustered after the data collection according to the European industry standard classification system NACE (Nomenclature des activités économiques dans la Communauté Européenne) (European Commission 2008). Companies were classified by their core business. For example, a software development company for the construction sector would, thus, be subsumed under the NACE code “K.72.22 Other software consultancy and supply”. For simplification reasons, a synonym for the NACE classifications was derived and thus used in the following. The respective NACE codes and their synonyms can be found in Table E-1 in the Appendix.

Furthermore, the companies were divided into private and public sectors by analyzing the responses to the industrial sector (d3b1). Public or similar institutions in this study are universities and its departments, research institutions (e.g. Fraunhofer institute), data center, and hospitals (similar to Forge and Blackman 2006; here "academia and research" will be subsumed as "public sector"; Plaszczak and Wellner 2006, pp. 72-73).

3.4 Methodology of Analysis

3.4.1 Ordinal Scale

It should be noted that measuring in social sciences is limited to observing attributes and characteristics of an object and not the object as a whole. Associated with this is the need for allotting numbers to the respective measuring procedure in an orderly manner (Bortz 1999, pp. 17-18), which is subject of the measure theory and will not be covered in detail in this work. Still, this theory bears upon this research, its measurements and the corresponding analysis to be undertaken.

Although metric-scales inhere various possibilities of calculating expected values and deriving linear or functional coherences, nominal- or ordinal-scaled data do not allow such projections (Hartung et al. 1999, p. 407). Likert-scales, strictly speaking, form part of ordinal measuring scales (Babbie 1995, p. 177) and are—from a mere statistical point of view—consequently limited in their analysis. In behavioral sciences, however, varied interpretations of this fact exist. Yet, taking on a liberal perspective in presuming interval-scaled data and respectively using all corresponding analyzing tools in practice has enriched the theory of the measured object significantly (Bortz 1999, pp. 27-29).

Nevertheless, the quantity of retained responses, missing values and the manner of sampling restrict this procedure in this study. Therefore, analyzing the descriptive data, distributions and correlations while interpreting the Likert-scale as ordinal-scale appears to produce more well-founded insights and promises more reliable results.

3.4.2 Correlations

As this is one of the first empirical studies concerning TCO concepts and security issues, I am mostly interested in exploring associations within the measured items. Therefore, the correlation coefficient is a feasible tool. Correlations depict how strong two variables are linearly related to one another. However, it is important to take a look at a scatter plot (see Figure A-1, p. 89) to verify whether a linear relation does indeed exist or if other patterns prevail. In the analysis, a look at the underlying data will also be taken in order to verify the scatter plot results.

In the analysis, I will use Kendall's rang correlation τ (Abdi 2007; Siegel 1956, pp. 213-223) as the used scale was interpreted as ordinal scale. Pearson's product-moment correlation does, therefore, not apply in this study as it calculates a linear association between two interval-scaled variables that are normally distributed (Siegel 1956, p. 213).

A convention of classifying correlations (Table 3-2) is given in Cohen (1988, pp. 79-81):

Table 3-2. Convention of classifying correlations (based on: Cohen 1988, pp. 79-81)

Correlation	Positive	Negative
Small	0.10 to 0.29	-0.10 to -0.29
Medium	0.30 to 0.49	-0.30 to -0.49
Large	0.50 to 1.00	-0.50 to -1.00

All correlation coefficients are displayed in Appendix F.1 (p. 105). In the following, only significant correlations at the 0.05- or 0.01-level will be considered and described. All significances were calculated as two-tailed since no definite direction of impact was predetermined.

3.4.3 Non-parametric Tests

As private and public sector as well as company size (i.e. SMEs and enterprises) constitute variates, the question of independence between these groups and their answering patterns arises. For this purpose, parametric and non-parametric tests are being used.

However, parametric tests are always bound to specific statistical requirements and restrictions. These conditions include certain forms of distribution in the underlying population or its parameters. Although further tests were developed to check the applicability of the necessary population characteristics from the sample, these tests are also bound to parametric preconditions. In case of small samples and doubts in using parametric tests, using non-parametric tests is advised. (Bortz and Lienert 2003, p. 59)

Although the χ^2-distribution is an important test distribution, it is only applicable if $N \to \infty$ as it then approximates to the χ^2 distribution (Bortz and Lienert 2003, p. 47). In addition, the data has to be drawn by random sampling (Janssen and Laatz 2005, p. 255). An acceptable approximation using the χ^2-test is supposed with a minimum of five responses per cell (Baltes-Götz 2007, p. 164). With samples between 20 and 60, usually a revised χ^2-test by Yates is used for testing the independence of variables in contingency tables (Hartung et al. 1999, p. 414). However, if strong asymmetries in the contingency table occur (Hartung et al. 1999, p. 414) or cells with less than five responses exist—as is the case in this research; even after reducing the scales to only two or three categories—tests based on the χ^2-distribution do not produce valid results and exact tests are advised.

Hence, Fisher's exact test can be employed as it does not suppose any approximation but utilizes the actually occurring distribution. As Fisher's exact test can only be employed for 2x2 tables, a generalized test of independence for 3x2 tables (Freeman-Halton test) will be applied first (Bortz and Lienert 2003, pp. 92-93; Hartung et al. 1999, pp. 414-415). Subsequently, the three-step scale will be reduce to two categories in order to deploy Fisher's exact test. Thus, as all items were formulated positively, the category neutral ("o") will be collapsed with the negative category ("-"). Fisher's test then allows formulating one-tailed hypotheses that can be tested for significance. Thus, directional hypotheses could be derived in the following.

Yet, the following tests of independence are explorative tests of significance. They are, therefore, not to be confounded with hypothesis testing. In the latter case, the research hypothesis (a-priori hypothesis) has to be defined before the survey instrument will be developed and the questionnaire is conducted. Nevertheless, quantitative explorative studies permit to compute significance tests if interesting effects can be observed. However, these tests on trial can—in no case—serve as an explication for a hypothesis as every event can be easily explained afterwards, but rather as a tool to verify if the effect that was pinpointed is rather significant in order to prepare further, more detailed hypotheses (Bortz and Döring 2006, pp. 379-380).

Moreover, directional and non-directional hypotheses have to be distinguished. A directional hypothesis postulates in which direction two variables are, for example, positively or negatively correlated. The non-directional hypothesis, on the other hand, would only state that a relation between these two variables exists. Directional hypothesis, though, are more precise and, thus, constitute a more desirable research proposition (Bortz and Döring 2006, pp. 7-8).

When testing for hypothesis, Type I and Type II errors can be committed. Rejecting the H_0 although being true is a Type I error with the probability of *p (Type I) = α*. Consequently, committing a Type II error with a probability of *p (Type I)* = β means accepting H_0 although it should be rejected. In turn, 1- β determines the power of the test, which increases with an increasing sample size. (Siegel 1956, pp. 8-11)

Apart from the size of the sample, a fourth variable is the effect ε determining in behavioral science if the tested effect is small, medium or large (Bortz and Lienert 2003). Before testing, three variables have to be defined in advance determining, in turn, the fourth. In research practice, $\alpha=0.05$ and $\beta=0.80$ are acceptable values. With the drawn sample, the effect is then the determined factor.

Another way of analyzing discrete data can be undertaken by exploring contingency tables. The analysis in this section will mainly rely on contingency tables and nonparametric tests. Only a small sample from the relatively small and hard-to-grasp community of Grid technology users was retained. Especially the section about business issues is missing a high degree of values. In addition, this study is one of the first quantitative approaches to obtaining insights into the attitude of businesses and research institutions towards Grid computing. Therefore, nonparametric tests constitute the best choice for analyzing this data for interconnections (Siegel 1956, p. vii).

In this research, only one sample was drawn from the research framework. Hence, company size (i.e. SME versus enterprises) as well as the category of private versus public sector can be considered as variates (Hartung et al. 1999, p. 412). Consequently, I am interested in analyzing the dependencies between these two groups separately. An overview of all responses and their allocation into these categories can be found in the Appendix (Table F-2; p. 106). In the following only interesting or strong differences between the groups will be examined in detail.

4 Results

The survey results were analyzed with the statistical software programm SPSS 15.0 for Windows® and Microsoft Excel 2003®. Figures and Tables in this thesis were also constructed with these programmes.

4.1 Sample Characteristics

All of the respondents were familiar with Grid computing (d1a1). Thereof, 46% use Grid computing already in their own business. Twenty-nine percent have not yet implemented Grid technologies and the remaining 25% are undecided (d1a2).

In addition, the Grid experts were able to select in which of the three categories—IT-service provider, application provider or IT-service consumer—their company could be classified (d3b4). Multiple answers were possible. Thus, 46% of the responding companies and institutions represented IT-service provider, the category application provider subsumed 50% of the sample and 38% are IT-service consumer. Some company representatives also reported to be Grid infrastructure provider, broker, or consultant.

Clustering the responses by NACE codes yielded the clustering according to industrial sectors shown in Figure 4-1. Thus, the sectors health, software development, and consulting are the most represented sectors with 21% each; followed by the research sector with 13%. Eight percent of the respondents were from the automotive sector. Moreover, the sectors air transport, telecommunications, university, and finance / banking were each represented with 4% in the survey.

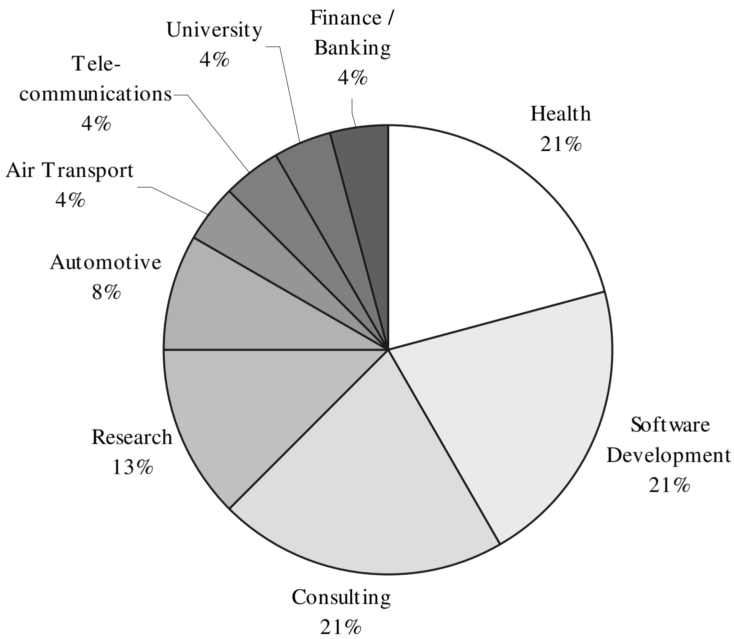

Figure 4-1. Industrial Sectors (Source: Author)

After separating public and private institutions, 71% of the respondents were from the private sector. The remaining 29% worked in public institutions.

According to the recommendation of the European Commission (European Commission 2003), SMEs employ less than 250 workers. Table 4-1 thus shows that over 50% of the respondents fall into this category regarding company size (d3b2). Slightly less can be categorized as large-scale enterprises (referred to as "enterprises" in the following).

Table 4-1. Responses by company size according to employment

Company Size		**SME (%)**			**Large-Scale Enterprise (%)**		
(# of Employees)		1-10	11-50	51-250	251-500	501-1000	>1000
Number	N=24	0	29	25	8	4	33
Total	100%		54			46	

According to the country of origin (d3b5), the majority of responses were received from Germany (70%). Spain and Israel were represented by 8% each. Italy, Pakistan and the United Kingdom complete the sample by 4% each.

4.2 Univariate Analysis

Primarily, the descriptive data will be analyzed item by item. Subsequently, bivariate analyses will examine inter-item dependencies.

Table 4-2. Frequencies of the surveyed items (N=24 unless specified)

	Items (N=24)	Frequencies (%) +	o	-
d1b1	Total Cost of Ownership concepts are being used in my business in order to evaluate the efficiency of IT investments.	71	17	13
d1c2	TCO-calculations are of major importance in my business. (N=22)	50	33	8
d1c1	TCO concepts are sufficient for the evaluation and the management of IT-costs.	38	33	29
d1c2	TCO concepts are sufficient for the evaluation and the management of Grid computing expenditures.	21	13	67
d1d1	Grid computing has the potential to reduce the TCO.	71	25	4
d1d2	The intention to reduce TCO justifies the use of Grid computing applications in my business.	58	25	17
d1e1	Grid computing has the potential to improve the Quality of Service (QoS).	46	29	25
d1e2	The intention to increase the QoS justifies the use of Grid computing applications in my business.	54	13	33
d2a1	Security has a high priority when using in-house IT-services.	88	0	13
d2a2	Security has a high priority when using external IT-services.	100	0	0
d2b1	Security concerns are an obstacle for the acquisition of IT-services by an external service provider.	63	33	4
d2b2	Security concerns are an obstacle for the acquisition of IT-services by a department service provider.	21	33	46
d2c1	Grid computing applications are suitable for offering standardized services.	71	21	8
d2c2	Grid computing applications are suitable for offering customized services.	46	25	29
d2d1	Information about the past behaviour of external IT-service providers is important for the service selection.	88	13	0
d2d2	I would use publicly accessible information (e.g. in form of an ebay-like evaluation system) for the service selection.	50	42	8
d2d3	I would publicly make available my personal experience regarding trustworthiness of service providers.	38	50	13
d2e2	A high integration of grid computing applications into existing implementations is important.	83	17	0
d2e3	External services should be accessed transparently.	83	17	0
d3a1	In the future, Grid computing will play a decisive role in the IT sector.	75	21	4
d3a2	In the future, Grid computing will play a decisive role in my business.	58	33	8

d1b1. Total Cost of Ownership concepts are used in nearly 71% of the surveyed companies and institutions. Thirteen percent disagree and 17% do not exactly know if their companies make use of TCO (see Table 4-2).

d1c1 and d1c2. The answering pattern for question d1c1 is not that distinct. Thirty-three percent of the respondents are indifferent or unsure, 29% disagree with this statement, whereas 38% agree that TCO concepts are sufficient for the evaluation and the management of IT-costs.

A different situation can be seen regarding TCO concepts for evaluating and managing Grid computing resources (d1c2). Sixty-seven percent of all respondents do not believe that TCO concepts are sufficient in that respect. Only 21% agree, 13% are indifferent.

d1d1 and d1d2. Seventy-one percent believe that Grid computing has the potential to reduce the Total Cost of Ownership (d1d1). On the contrary, 4% disagree and 25% are not in favor of either side.

Fifty-eight percent infer that the intention to reduce the TCO justifies the use of Grid technologies (d1d2). Twenty-five percent were diffident in assenting or dissenting to this statement whereas 17% objected the expression.

d1e1 and d1e2. Regarding the potential of Grid computing to reduce the QoS, 46% perceive this being the case while 25% oppose to this statement. Twenty-nine percent are indifferent in this case.

Fifty-four percent agree that the potential of increasing the QoS justifies using Grid computing applications in their business. On the other hand, 33% rejected this statement. Only 13% remain unsure.

d2a1 and d2a2. For using in-house IT-services, the majority of 88% believes that security aspects have a high priority (d2a1). In contrast, 13% disagree with this proposition. All of the respondents agreed on security being very important when using external IT services (d2a2).

d2b1 and d2b2. While acquiring IT services by an external service provider, 63% view security as a possible obstacle in this process (d2b1). Thirty-three percent are hesitant, only 4% object security being an obstacle for external IT services.

For IT services acquired from in-house service providers, 21% view security as an obstacle (d2b2), 33% are indecisive leaving 46% rejecting the statement.

d2c1 and d2c2. Concerning the range of the possible applicability of Grid computing technologies, 71% accredit Grid computing being suitable for offering standardized services (d2c1). Only 8% of the surveyed companies deny this capability. However, 21% remain undecided.

The proposition that Grid computing applications are suitable for customized services (d2c2) is supported by 46%. Unsure of agreeing or disagreeing were 25%. Twenty-nine percent still challenged the suitability in this case.

d2d1, d2d2 and d2d3. The vast majority of 88% complies with information about the past behavior of external IT-service providers being important for the service selection (d2d1). None of the respondents contested the statement, only 13% were unsure.

For the service selection, 50% would make use of publicly accessible information (e.g. in form of an eBay-like evaluation system) (d2d2). Eight percent would not use these information and forty-two percent considered remaining neutral towards this statement.

Of all the respondents, 38% would publicize their personal experiences regarding the trustworthiness of service providers. On the other hand, 13% would not announce such information publicly. The remaining fifty percent stay diffident.

d2e1. Among the eight mentioned technical standards (Web Services, individual XML messages, SOA standards, CORBA, Java messages, component-based messages, EDI, and IDoc), Web Services were the most commonly used method. Ninety-two percent responded to utilize Web Services for internal and external communication in their company (Figure 4-2). Individual XML messages were exploited by 71%, followed by SOA standards (63%). CORBA and Java messages share fourth place with both 42%. Moreover, 25% of the surveyed businesses and institutions use component-based messages respectively EDI. Only a minority of 13% interchanges data in business transactions with IDoc.

Some of the respondents also mentioned OGC® (Open Geospatial Consortium) Web services, HL7 (Health Level 7) as well as CDISC (Clinical Data Interchange Standards Consortium) as used standards for internal and external communication in their businesses.

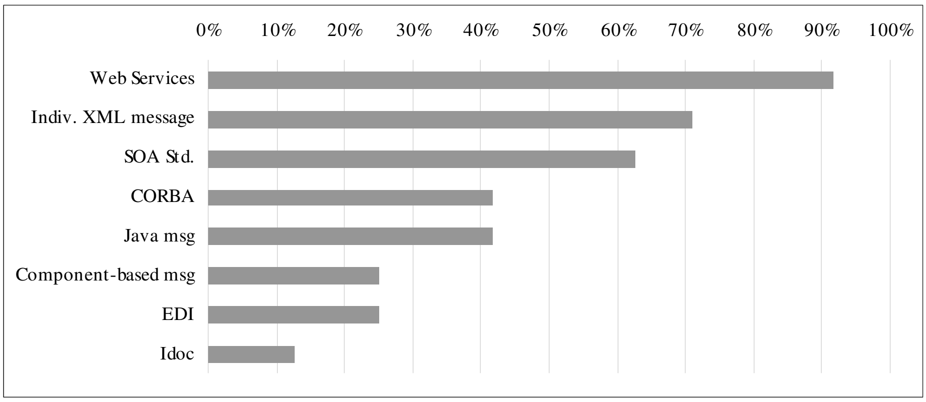

Figure 4-2. Technical standards used for data interchange (Source: Author)

d2e2. Concerning the integration of Grid computing into already existing implementations, 83% believe that a high degree of integration is important; in contrast to 17% who remain uncertain. None of the respondents denies a certain importance of integrating Grid computing into the existing architecture.

d2e3. Eighty-three percent also consider accessing external services transparently as being important. None of the company representatives disagreed, only 17% were uncertain.

d3a1 and d3a2. As regards the future of Grid computing, 75% of the companies assume that Grid computing will play a decisive role in the IT sector (d3a1). Twenty-one percent were hesitant and a small minority (4%) did not imagine such an important impact of the technology on the IT sector.

Moreover, Grid computing will play a decisive role in their companies (d3a2) say 58%. Eight percent negate this proposition, whereas 33% were rather undecided.

4.3 Bivariate Analysis

4.3.1 Correlations

An overview of all inter-item correlations is to be found in Table F-1 (p. 105) in the Appendix. As d1a1 and d1b2 were considered control variables respectively were excluded from the univariate analysis, both items therefore do not appear in the bivariate analysis. However, although both d1a2 and d1b1 were also conceived as control variables, correlations to these items might reveal interesting insights into interconnections.

d1b1 and d2b2. If companies use TCO (d1b1), then 55% think that these concepts are very important (d1b2; see Table 4-3). Only 5% reject this statement for their business and 18% are neutral. If the respondents were not sure if TCO was used in their company, they also reported the same for the importance in their company (14%). On the contrary, those companies that do not use TCO concepts also reject a high importance in their company (5%) or remain undecided (5%). The two additional respondents that were excluded in this analysis were either unsure if the TCO concept was employed or do not use TCO.

Table 4-3. Importance of TCO concepts (d1b1 and d1b2)

Items		**d1b1**		
N=22		+	o	-
d1b2	+	55	0	0
	o	18	14	5
	-	5	0	5

Here, two more responses were excluded for an equal number of responses for each item. The percentages are based on twenty-two answers. Integers represent rounded percentages

d1a2 and d1b1. A significant medium correlation (τ=0.44; $p<0.05$) can be found between using Grid technologies (d1a2) and employing TCO concepts in one's own business (d1b1). Though, since both of the variables were treated as control variables, the correlation was calculated from a reduced three-step scale (“+”, “o”, and “-“).

Table 4-4. Inter-item frequencies between d1a2 and d1b1. Integers represent rounded percentages

Items		**d1b1**		
N=24		+	o	-
d1a2	+	38	25	8
	o	4	0	13
	-	4	0	8

Therefore, observing the underlying numbers (Table 4-4) or the scatter plot (see Figure A-1, p. 89), one realizes that the responses are more diverse and less linearly related than the correlation coefficient would suggest at first sight. Still, the majority of 38% of Grid users also utilizes TCO concepts.

d1a2 and d1d1 / d1d2. d1d1 (τ=0.63; p<0.01) respectively d1d2 (τ=0.62; p<0.01) are highly correlated with d1a2. The scatter plot and the numbers (Table 4-5) somewhat support the tendency towards a linear relation between these items.

Table 4-5. Inter-item frequencies between d1a2 and d1d1 respectively d1d2. Integers represent rounded percentages

Items		**d1d1**					**d1d2**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD
d1a2	+	29	8	4	4	0	21	13	8	4	0
	o	0	17	8	0	0	0	4	13	8	0
	-	0	4	13	4	8	4	4	8	8	4

d1a2 and d1e1 / d1e2. The correlation coefficient depicts a medium correlation (τ=0.42; p<0.05) between those companies that make us of Grid technologies (d1a2) and those that believe Grid computing has the potential to increase the QoS (d1e1). Thirty-four percent of the representatives either agree or strongly agree that Grid computing inherits this potential if they already employ this technology (Table 4-6).

Table 4-6. Inter-item frequencies between d1a2 and d1e1 respectively d1e2. Integers represent rounded percentages

Items		**d1e1**					**d1e2**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD
d1a2	+	21	13	8	4	0	17	21	0	8	0
	o	0	4	13	8	0	0	13	4	8	0
	-	4	4	8	8	4	0	4	8	8	8

Similarly, a large correlation ($\tau=0.53$; $p<0.01$) is to be seen between Grid users (d1a2) and those who reckon that the use of Grid is justified because of the intention to increase the QoS (d1e2). Table 4-6 also exposes that 38% who use Grid already also tend to infer using Grid because of this fact (17% strongly agree and 21% agree). Yet, 16% who do not employ Grid computing likewise perceive no justification in using Grid to increase the QoS.

d1a2 and d3a2. An important role in one's own business in the future (d3a2) and the utilization of Grid technologies (d1a2) hold a medium inter-item correlation of $\tau=0.44$ ($p<0.05$). Although the scatter plot and the underlying numbers stress this linear interconnection, reducing the response categories of d3a2 to three dimensions (Table 4-7) uncovers less linearity between positive, neutral or negative responses of these two statements.

Table 4-7. Inter-item frequencies between d1a2 and d3a2. Integers represent rounded percentages

Items		**d3a2**							
N=24		SA	A	N	D	SD	+	o	-
d1a2	+	13	21	13	0	0	33	13	0
	o	0	17	8	0	0	17	8	0
	-	0	8	13	8	0	8	13	8

The right part of the table reflects a reduction of dimensions of the percentages to its left.

d1b1 and d2e3. A correlation of $\tau=0.46$ ($p<0.05$) implies a medium linearity between using TCO concepts (d1b1) and the proposition that external services should be accessed transparently (d2e3). The scatter plot (see Figure A-1, p. 89) exposes only nine data cells with a vast accumulation of responses in agreeing to d1b1 as well as d2e3.

The underlying data (Table 4-8) backs this observation. Thus, none of the surveyed companies disagreed that external services should be accessed transparently. Yet, 71% use TCO concepts and also agree to transparent access.

Table 4-8. Inter-item frequencies between d1b1 and d2e3. Integers represent rounded percentages

Items		**d2e3**				
N=24		SA	A	N	D	SD
d1b1	+	46	25	0	0	0
	o	4	4	8	0	0
	-	0	4	8	0	0

d1c1 and d1c2. A positive correlation between d1c1 and d1c2 exists meaning people thinking that TCO concepts are sufficient for the management of IT resources also tend to believe that this will be the case with Grid resources as well (τ=0.57; $p<0.01$). A look at the scatter plot in Figure A-1 (see p. 89) or Table 4-9 reveals a linear relation between the two items. However, of those that negate the sufficiency of TCO within Grid environments, seventeen percent think that TCO can be utilized for the management and the evaluation of IT costs; twenty-nine percent disagree; and 21% remain undecided (Table 4-9).

Table 4-9. Inter-item frequencies between d1c1 and d1c2. Integers represent rounded percentages

Items		**d1c2**								
N=24		SA	A	N	D	SD		+	o	-
d1c1	SA	4	0	0	0	0	+	17	4	17
	A	4	8	4	17	0	o	4	4	21
	N	4	0	8	17	4	-	0	0	29
	D	0	0	0	17	0				
	SD	0	0	0	0	13				

The right part of the table reflects a reduction of dimensions of the percentages to its left.

d1c2 and d2b1. One of the significant negative correlations (-0.42; $p<0.05$) exists between the items d1c2 (TCO concepts are sufficient for the management and evaluation of Grid expenditures) and d2b1 (security concerns are an obstacle for the acquisition of IT-services by an external provider).

Table 4-10. Inter-item frequencies between d1c2 and d2b1. Integers represent rounded percentages

Items		**d2b1**								
N=24		SA	A	N	D	SD		+	o	-
d1c2	SA	4	4	0	0	4	+	8	8	4
	A	0	0	8	0	0	o	4	8	0
	N	0	4	8	0	0	-	50	17	0
	D	21	13	17	0	0				
	SD	13	4	0	0	0				

The right part of the table reflects a reduction of dimensions of the percentages to its left.

In this case, however, the scatter plot and Table 4-10 permit a somewhat different perspective at the data. The correlation of the five-scaled items does reflect a certain negative tendency between d1c2 and d2b1. When combining the categories to form a three-folded scale (exemplified on the right hand side of Table 4-10) however, already 50% of the respondents negate d1c2 but on the other hand agree to d2b1. Thus, a linear relation between the two items is questionable. It can be noted, however, that representatives who view security concerns as possible obstacles for the acquisition of external IT-services tend to hold the view that TCO concepts are rather insufficient regarding the evaluation and management of Grid computing expenditures.

d1d1 / d1d2 and d1e1 / d1e2. Significant correlations between all of the four items d1d1, d1d2, d1e1, and d1e2 can be observed. The inter-item correlation between d1d1 (Grid computing has the potential to reduce the TCO) and d1d2 (The intention to reduce TCO justifies the use of Grid computing applications in my business) amounts to $\tau=0.71$ ($p<0.01$). Additionally, the items Grid computing has the potential to improve the QoS (d1e1) and the intention to increase the QoS justifies the use of Grid computing applications in my business (d1e2) also feature a strong correlation ($\tau=0.74$; $p<0.01$). Both of these linear dependencies can also be certified by the scatter plot.

If one analyzes d1d1 and its relations further, large correlations with d1e1 (0.57; $p<0.01$) and d1e2 (0.64; $p<0.01$) exist. The same situation applies to d1d2 whose correlations coefficients with d1e1 and d1e2 can be calculated as $\tau=0.46$ ($p<0.01$) and $\tau=0.72$ ($p<0.01$) respectively.

Table 4-11. Inter-Item frequencies between d1d1, d1d2, d1e1, and d1e2. Integers represent rounded percentages

Items		**d1d2**					**d1e1**					**d1e2**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD	SA	A	N	D	SD
d1d1	SA	29	8	4	0	0	25	8	4	4	0	17	21	0	4	0
	A	0	17	8	4	0	0	8	13	8	0	0	13	8	8	0
	N	0	4	13	4	4	0	4	13	8	0	0	4	4	13	4
	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	4	0	0	0	0	4	0	0	0	0	4
d1d2	SA						21	4	4	0	0	17	13	0	0	0
	A						0	8	13	8	0	0	17	8	4	0
	N						4	4	4	13	0	0	4	4	17	0
	D						0	4	4	0	0	0	4	0	4	0
	SD						0	0	4	0	4	0	0	0	0	8
d1e1	SA											17	8	0	0	0
	A											0	17	4	0	0
	N											0	13	4	8	4
	D											0	0	4	17	0
	SD											0	0	0	0	4

d1d1 and d2c1 / d2c2. Moreover, the item Grid computing has the potential to reduce the TCO (d1d1) is also correlated to the item d2c1 (Grid computing applications are suitable for offering standardized services) with $\tau=0.36$ ($p<0.05$) and d2c2 (Grid computing applications are suitable for offering customized services) with $\tau=0.39$ ($p<0.05$).

If the data is analyzed more closely (Table 4-12), it can again be concluded that a rather linear relation between the categories strongly agree to neutral of d1d1 and the other categories of d2c1 and d2c2.

Table 4-12. Inter-item frequencies between d1d1 and d2c1 respectively d2c2. Integers represent rounded percentages

Items		**d2c1**					**d2c2**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD
d1d1	SA	17	21	0	4	0	8	17	8	4	4
	A	0	17	13	0	0	4	13	13	0	0
	N	4	13	8	0	0	0	4	4	17	0
	D	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	4	0	0	0	0	4

d1d1 and d3a2. Those company representatives granting Grid computing the potential to reduce the TCO (d1d1) also tend to believe that Grid technologies will play an important role in their own business (d3a2). The correlation between the two items amounts to τ=0.38 ($p<0.05$). Yet, in the scatter plot the data seems to be clustered. In fact, 92% of all answers regarding d1d1 and d3a2 are located in the upper left corner of Table 4-13.

Table 4-13. Inter-item frequencies between d1d1 and d3a2. Integers represent rounded percentages

Items		**d3a2**				
N=24		SA	A	N	D	SD
d1d1	SA	8	21	13	0	0
	A	4	17	8	0	0
	N	0	8	13	4	0
	D	0	0	0	0	0
	SD	0	0	0	4	0

d1e1 / d1e2 and d2c2. Furthermore, a medium correlation of τ=0.38 ($p<0.05$) is to be observed between seeing the potential of Grid computing in increasing the QoS (d1e1) and believing that Grid technologies are suitable for offering customized services (d2c2). Still, the scatter plot and the underlying responses (Table 4-14) would not support such a clear correlation.

The same correlation exists between d1e2 and d2c2. The correlation coefficient also amounts to τ=0.38 ($p<0.05$).

Table 4-14. Inter-item frequencies between d1e1 and d2c2. Integers represent rounded percentages

Items		**d1e1**					**d1e2**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD
d2c2	SA	8	0	4	0	0	8	4	0	0	0
	A	13	8	4	8	0	4	17	0	13	0
	N	4	8	4	8	0	4	4	13	4	0
	D	0	4	13	4	0	0	8	0	8	4
	SD	0	0	4	0	4	0	4	0	0	4

d1e1 / d1e2 and d3a2. d1e1 and d1e2 are also both significantly correlated to d3a2 with a coefficient of $\tau=0.42$ ($p<0.05$) respectively $\tau=0.45$ ($p<0.05$). But, as one could observe with other items before, Table 4-15 reveals that a linear relation exists between the categories strongly agree and neutral (d3a2) and the other two items.

Table 4-15. Inter-item frequencies between d1e1 / d1e2 and d3a2. Integers represent rounded percentages

Items		**d1e1**					**d1e2**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD
d3a2	SA	8	4	0	0	0	8	4	0	0	0
	A	8	17	13	8	0	4	21	8	13	0
	N	8	0	13	13	0	4	13	4	13	0
	D	0	0	4	0	4	0	0	0	0	8
	SD	0	0	0	0	0	0	0	0	0	0

d2a1 and d2a2. Furthermore, d2a1 and d2a2 exhibit a medium correlation ($\tau=0.41$; $p<0.05$). All of the respondents agreed to security aspects being important in using external IT-services (d2a2). Thus, most of those who agreed to d2a2 also supported the proposition d2a1 (88%). Only 12% who associated a high priority of security with using external IT-services did not feel similar about in-house IT-services and disagreed with this statement (Table 4-16).

Table 4-16. Inter-item frequencies between d2a1 and d2a2. Integers represent rounded percentages

Items		**d2a2**				
N=24		SA	A	N	D	SD
d2a1	SA	50	0	0	0	0
	A	25	13	0	0	0
	N	0	0	0	0	0
	D	8	4	0	0	0
	SD	0	0	0	0	0

d2b1 and d2d2. Looking at the scatter plot for the relation between d2b1 and d2d2, one can observe that the responses are clustered to a certain extent, with an outlier apparently supporting a linear relation with a correlation of $\tau=0.38$ ($p<0.05$). Table 4-17 thus reveals that 42% of the company representatives agreed to d2b1 and d2d2 simultaneously. Twenty-five percent remain neutral to both statements, and 25% are in favor of one statement and undecided to the other.

Table 4-17. Inter-item frequencies between d2b1 and d2d2. Integers represent rounded percentages

Items		**d2d2**				
N=24		SA	A	N	D	SD
d2b1	SA	4	21	8	4	0
	A	0	17	8	0	0
	N	0	8	25	0	0
	D	0	0	0	0	0
	SD	0	0	0	0	4

d2c1 and d2d2. A similar result can be noted between d2c1 and d2d2. The correlation amounts to $\tau=0.39$ ($p<0.05$). Although, the scatter plot bears resemblance to a linear connection between these two items, the underlying numbers (left-hand side of Table 4-18) would attenuate this estimation. Ninety-two percent of the responses are accumulated between strongly agree and neutral of both items. Yet, 42% of the surveyed companies agreed to d2c1 and d2d2 at the same time.

Table 4-18. Inter-item frequencies between d2c1 and d2d2 (left) and d2c1 and d3a1 (right). Integers represent rounded percentages

Items		**d2d2**					**d3a1**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD
d2c1	SA	4	8	8	0	0	21	0	0	0	0
	A	0	29	21	0	0	13	25	13	0	0
	N	0	8	13	0	0	8	8	4	0	0
	D	0	0	0	4	0	0	0	0	4	0
	SD	0	0	0	0	4	0	0	4	0	0

d2c1 and d3a1. Yet another similar case emerges with the correlation between d2c1 and d3a1 (τ=0.47; p<0.01). Table 4-18 (right-hand side) depicts that 92% of the respondents agree or remain neutral towards both items. Fifty-eight percent, in turn, believe that Grid computing is suitable for standardized services and predict a decisive role for Grid in the IT-sector in the future.

d2c2 and d3a1 / d3a2. Furthermore, the correlation matrix uncovers two significant correlations at the 0.01-level between d2c2 and d3a1 (τ=0.46) respectively d3a2 (τ=0.53). Although the scatter plot shows a scattered distribution of responses between d2c2 and d3a1, Table 4-19 shows that a slight linear tendency exists between these items. As compared to d3a1, the responses to d2c2—according to the categories agree, neutral and disagree—are more diverse. Therefore, it seems that those representatives that disagree with or are undecided towards the applicability of Grid technologies for customized services also tend to agree less strongly or are sceptical about a future important role of Grid computing in the IT-sector.

Table 4-19. Inter-item frequencies between d2c2 and d3a1 respectively d3a2. Integers represent rounded percentages

Items		**d3a1**					**d3a2**				
N=24		SA	A	N	D	SD	SA	A	N	D	SD
d2c2	SA	8	4	0	0	0	4	8	0	0	0
	A	25	4	0	4	0	8	17	8	0	0
	N	4	17	4	0	0	0	13	13	0	0
	D	4	4	13	0	0	0	8	8	4	0
	SD	0	4	4	0	0	0	0	4	4	0

Correlating d2c2 to d3a2—concerning the future of Grid technologies in the respondent's own company—results in a large correlation as mentioned above. The fundamental data, displayed on the right-hand side of Table 4-19, suggests that respondents who disagreed with d2c2 also remain either diffident towards or disagree with d3a2.

d2d1 and d3a2. Negatively correlated are d2d1 and d3a2 (τ= -0.38; $p<0.05$). This might be supported by the scatter plot, but the actual numbers (Table 4-20) reflect a slightly different picture. Forty-six percent of the survey companies agree to both d2d1 and d3a2. Moreover, another 46% were unsure towards one of the propositions. Thirty-four percent that agreed to d2d1 remained undecided towards d3a2, 8% disagreed.

Table 4-20. Inter-item frequencies between d2d1 and d3a2. Integers represent rounded percentages

Items		**d3a2**				
N=24		SA	A	N	D	SD
d2d1	SA	0	17	17	4	0
	A	4	25	17	4	0
	N	8	4	0	0	0
	D	0	0	0	0	0
	SD	0	0	0	0	0

d2d2 and d2d3. The inter-item correlation between d2d2 and d2d3 amounts to τ=0.38 ($p<0.05$). In addition to what was already described in the univariate analysis of both items, 58% of all respondents are unsure of one or the other proposition (Table 4-21). The data is, therefore, rather grouped around the options agree and neutral of both items—when combining the values, 75% of all responses fall within this interval.

Table 4-21. Inter-item frequencies between d2d2 and d2d3. Integers represent rounded percentages

Items		d2d3				
N=24		SA	A	N	D	SD
d2d2	SA	4	0	0	0	0
	A	4	17	21	4	0
	N	0	13	25	4	0
	D	0	0	4	0	0
	SD	0	0	0	0	4

d3a1 and d3a2. Additionally, d3a1 and d3a2 feature a strong correlation ($\tau=0.61$; $p<0.01$) suggesting that those who predict an important role for Grid computing in the IT sector (d3a1) will also assume a similar role in their business in the future (d3a2). Still, Table 4-22 shows that 21% (neutral) are rather sceptical about the Grid future in their own company even if they agree with d3a1.

Table 4-22. Inter-item frequencies between d3a1 and d3a2. Integers represent rounded percentages

Items		d3a2				
N=24		SA	A	N	D	SD
d3a1	SA	13	25	4	0	0
	A	0	17	17	0	0
	N	0	4	8	8	0
	D	0	0	4	0	0
	SD	0	0	0	0	0

4.3.2 Contingency Tables

4.3.2.1 Public versus Private Sector

d1c1. The first difference in the answering patterns between the public and private sector is to be seen in item d1c1 (Figure 4-3; see p.60). Forty-seven percent of the private companies believed that TCO are sufficient for the evaluation and management of IT costs, whereas only 14% agreed in the public sector. On the contrary, relatively more public respondents remained neutral (57%) compared to private representatives (24%).

d1d1. All public representatives regarded Grid computing as potentially able to reduce the TCO. In contrast, only 59% of the private companies were of the same opinion. Thirty-five percent were unsure, 6% negated this statement (Figure 4-3).

d1e1. In the public sector, 71% considered Grid computing having the potential to increase the QoS. The private sector in turn was rather skeptical, only 35% also agreed on this proposition. Another 35% of the private companies were neutral towards d1e1 and the remaining 29% disagreed. Only 14% of the public institutions were unsure or respectively objecting d1e1 (Figure 4-3).

d1e2. Similarly, 71% of the public sector also agreed to d1e2, thus applying Grid applications if one intents to increase the QoS. Fourteen percent either rejected d1e2 or felt unsure. In the private sector, only 47% also agreed to d1e2. On the other hand, 41% opposed this statement and 12% hesitated (Figure 4-3).

d2d3. In addition, 57% of all public institutions would publicize their personal experiences regarding the trustworthiness of service providers. The remaining 43% hesitated. The private sector responded more diverse. The majority (53%) was unsure and remained neutral. Twenty-nine percent complied with the proposition, which on the other hand 18% rejected (Figure 4-3).

d2e2. Another difference in answering patterns between these two sectors can be noted regarding the integration of grid computing applications into existing implementations (d2e2). The majority of private sector respondents (94%) agreed that a high integration is necessary (Figure 4-3). Only 57% of the public institutions were of the same opinion. Another 43% in the public sector were neutral towards this statement, 6% felt similar on the private side.

d3a1 and d3a2. Furthermore—regarding the future role of Grid computing—all public institutions consent that Grid computing will play a decisive role in the IT sector. In contrast, sixty-five percent of the private representatives thought equally, 41% were unsure and 6% negated d3a1 (Figure 4-3).

Concerning the future role in one’s own business, 86% of the public sector believe Grid technologies will play a decisive role, whereas 14% were undecided. On the other hand, only 47% of private companies also supported d1e2. Forty-one percent were unsure and 12% disagreed (Figure 4-3).

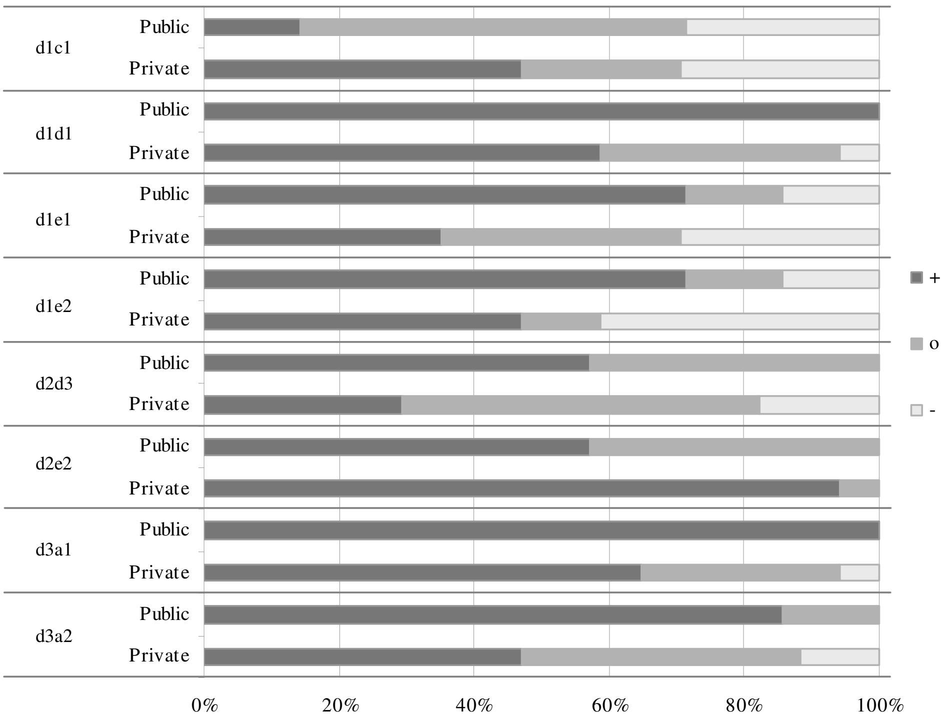

Figure 4-3. Obvious differences between public and private sector (Source: Author)

4.3.2.2 SMEs versus Large Enterprises

d1c1. One of the first stronger differences between SMEs and enterprises can be found concerning TCO concepts and their sufficiency to evaluate and manage IT-costs. Accordingly, 40% of the SMEs in this case held TCO to be satisfactory while another 40% rejected d1c1. Twenty percent were unsure. On the other hand, 57% of the enterprise respondents were also in favor of this proposition. Twenty-nine percent remained neutral and 14% disagreed (Figure 4-4; see p. 62).

d1d1. More diverse were the response patterns towards d1d1. Seventy percent of all private SMEs felt that Grid computing has the potential to reduce the TCO. Only 30% hesitated. In contrast, 43% of the enterprise representatives also agreed. Yet, only 14% objected d1d1 and the remaining 43% were unsure (Figure 4-4).

d2b2. Another difference between SMEs and enterprises becomes obvious while examining the views on the acquisition of internal IT-services and possible security obstacles. Forty-three percent of the enterprises are of the opinion that security concerns can denote a possible hindrance, whereas none of the SME representatives concurred. Both 50% of the SMEs were undecided or disagreed with d2b2. On the enterprise side, 43% objected this statement and 14% were diffident (Figure 4-4).

d2c1. Moreover, almost all of the SMEs believed that Grid computing is suitable for offering standardized services (90%). The remaining 10% were neutral. The surveyed enterprises responded more diverse: 43% similarly complied with d2c1, 29% were unsure and 29% dissented (Figure 4-4).

d2c2. As regards offering customized services, a difference can be spotted. Forty percent of the SMEs considered Grid computing suitable for offering these services, 40% also hesitated, whereas 20% negated this proposition. Concerning the enterprise representatives, 43% also consented with d2c2 while 57% rejected this statement (Figure 4-4).

d2d2. While 57% of the enterprise respondents would utilize publicly accessible information for the service selection, 14% were rather undecided and 29% would not make use of this information. On the other hand, 50% of the SMEs were unsure and 50% agreed (Figure 4-4).

d3a1. Another difference between enterprises and SMEs is unveiled by a closer look at d3a1. The majority of the SMEs were in favor of this statement (80%) with only 20% of the respondents being indecisive. On the contrary, 43% of the enterprise representatives perceived an important future role of Grid computing in the IT-sector. Forty-three percent remained neutral and 14% rejected d3a1 (Figure 4-4).

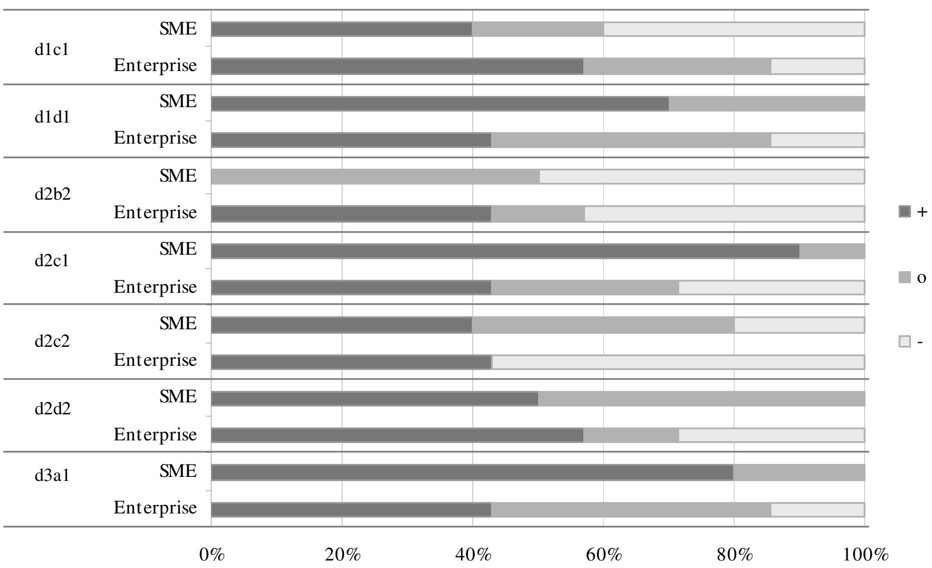

Figure 4-4. Obvious differences between SMEs and enterprises (Source: Author)

4.3.3 Significance Tests of Contingency Tables

4.3.3.1 Freeman-Halton Test

The contingency tables that will be examined for significances have been already described in the previous Ch. 4.3.2. In the following chapter, these tables will be tested for independency between the responding groups. Thus, I want to verify if the results obtained also represent significant results. The probabilities shown constitute two-tailed significances. The null hypothesis predicts that no difference exists between the two groups. The alternative hypothesis predicts that a difference exists and both groups are independent.

The results for some selected items that show differences between private and public sector can be found in Table 4-23. Under the asumption of α=0.05, the null hypothesis cannot be rejected. This implies that no significant difference between the two groups can be verified with the respective testing procedure.

The calculations of the significance tests can be found in Appendix F.

Table 4-23. Freeman-Halton test for selected items between private and public sector. With probabilities greater than α=0.05, the null-hypothesis cannot be rejected

Item		Private (#)	Public (#)	Probability (2-tailed)
	+	8	1	
d1c1	o	4	4	0.24
	-	5	2	
	+	10	7	
d1d1	o	6	0	0.17
	-	1	0	
	+	6	5	
d1e1	o	6	1	0.31
	-	5	1	
	+	8	5	
d1e2	o	2	1	0.47
	-	7	1	
	+	5	4	
d2d3	o	9	3	0.48
	-	3	0	
	+	16	4	
d2e2	o	1	3	0.06
	-	0	0	
	+	11	7	
d3a1	o	5	0	0.36
	-	1	0	
	+	8	6	
d3a2	o	7	1	0.23
	-	2	0	
Numbers		17	7	

The results for selected items that show differences between SMEs and enterprises can be found in Table 4-24.

Table 4-24. Freeman-Halton test for selected items between SMEs and Enterprises. With probabilities greater than α=0.05, the null-hypothesis cannot be rejected

Item		SME (#)	Enterprise (#)	Probability (2-tailed)
	+	4	4	
d1c1	o	2	2	0.57
	-	4	1	
	+	7	3	
d1d1	o	3	3	0.43
	-	0	1	
	+	0	3	
d2b2	o	5	1	0.07
	-	5	3	
	+	9	3	
d2c1	o	1	2	0.09
	-	0	2	
	+	4	3	
d2c2	o	4	0	0.12
	-	2	4	
	+	5	4	
d2d2	o	5	1	0.14
	-	0	2	
	+	8	3	
d3a1	o	2	3	0.19
	-	0	1	
Numbers		10	7	

4.3.3.2 Fisher's Exact Test

After I calculated the tests of independence with the Freeman-Halton test, I will now collapse the dimensions to 2x2. Consequently, the alternative hypothesis for all items is H_1: The fraction of one of the groups (private versus public respectively SME versus enterprises) that supports a statement ("+") is greater than the fraction of the other group that supports the statement. The null hypothesis, in turn, reads that the fraction of the first group is smaller or equal to the fraction of the last group. The one-tailed probabilities for private versus public institutions are to be found in Table 4-25.

Table 4-25. Fisher's exact test of selected items between private and public sector. With probabilities greater than α=0.05, the null-hypothesis cannot be rejected. Priv (Private Sector), Publ (Public Sector)

Item		Priv	Publ	Total	Probability (1-tailed)
d1c1	+	8	1	9	0.15
	o / -	9	6	15	
	Total	17	7	24	
d1d1	+	10	7	17	0.06
	o / -	7	0	7	
	Total	17	7	24	
d1e1	+	6	5	11	0.12
	o / -	11	2	13	
	Total	17	7	24	
d1e2	+	8	5	13	0.26
	o / -	9	2	11	
	Total	17	7	24	
d2d3	+	5	4	9	0.21
	o / -	12	3	15	
	Total	17	7	24	
d2e2	+	16	4	20	0.06
	o / -	1	3	4	
	Total	17	7	24	
d3a1	+	11	7	18	0.09
	o / -	6	0	6	
	Total	17	7	24	
d3a2	+	8	6	14	0.10
	o / -	9	1	10	
	Total	17	7	24	

The probabilities for SMEs versus enterprises can be found in Table 4-26. Compared to the Freeman-Holton test, the items d2c2 and d2d2 were excluded as—after collapsing—no obvious distinction could be found. Under the asumption of α=0.05, the null hypothesis cannot be rejected. This implies that the fraction of one group supporting the respective statement cannot be verified to be significantly greater than the fraction of the other group with the respective testing procedure.

Table 4-26. Test of independence of selected items according to company size. With probabilities greater than α=0.05, the null-hypothesis cannot be rejected. SME (Small- and Medium-sized Enterprises), Entrp (Enterprises)

Item		SME (#)	Entrp (#)	Total (#)	Probability (1-tailed)
d1c1	+	4	4	8	0.15
	o / -	6	3	9	
	Total	10	7	17	
d1d1	+	7	3	10	0.27
	o / -	3	4	7	
	Total	10	7	17	
d2b2	+	0	3	3	0.05
	o / -	10	4	14	
	Total	10	7	17	
d2c1	+	9	3	12	0.06
	o / -	1	4	5	
	Total	10	7	17	
d3a1	+	8	3	11	0.14
	o / -	2	4	6	
	Total	10	7	17	

5 Discussion, Evaluation, and Application of Results to open Grids

5.1 Discussion

5.1.1 Discussion of Grid Market Structure

5.1.1.1 Grid Market in General

In the conducted research, the corporate attitude towards several key issues and further requirements were examined. In the following, the characteristics of the market and its actors will be analyzed in order to discuss the key issues subsequently. After describing the limitations of the research, the findings will then be applied to an open Grid market.

Knowledge barrier-reducing institutions or—more specifically—consultancies are present. The research might not reflect the actual share of consultancies compared to service providers, application providers, or consumers within the market (here 21%). However, it serves as an empirical indicator for the theoretical predictions. Thus, consultancies are already spreading the word about Grid computing, the technological requirements, and its effect on business issues. They are supporting their customers in order to implement Grid computing and therefore reduce possible knowledge barriers.

As the commercial reports predicted the sectors automotive, finance and banking, or healthcare to be among the group of early adopters, these groups can also be found among the respondents of the survey. Thus, it can be concluded that either the companies themselves joined one of the research networks in order to obtain more information on Grid computing or to create a personal network for problem solving; or the early adopters were approached by researchers to examine their experiences with Grid computing more closely and to enhance—through exchange of information from the scientific and business background—the existing solutions.

Furthermore, those that already use Grid computing (d1a2) also tend to believe that Grid computing will have an important role in their company in the future (d3a2;

τ=0.44). Grid computing once employed therefore seems to fulfill the companies' needs for the challenges they have to solve. This is supported by the positive forecast for the future of Grid computing. Seventy-five percent believe Grid computing will have an important role in the IT sector (d3a1) and 58% believe that Grid computing will have an important role in their business (d3a2). This is supported by a strong correlation between the two items. Yet, several factors might influence these results. It could be argued that the representatives view the Grid computing technology as viable for the future because of its great potential. This in turn might influence the tendency to view Grid computing important in the future of one's own company. It could also be possible that those using Grid in their company predict a great future within the IT sector because being influenced by the results they achieved. However, their situation might not be applicable to companies not using Grid computing yet. Moreover, the mentioned pro-innovation bias might also influence the attitude of the respondents in that they answer more positively regarding the future of Grid computing.

Although a tendency to support the statements that Grid computing reduces the TCO and increases the QoS can be observed, slight differences among the respondents still exist. Seventy-one percent of the respondents hold Grid computing suitable for reducing the Total Cost of Ownership (d1d1), whereas only 46% hold Grid computing suitable for increasing the Quality of Service (d1e1).

Nonetheless, as it can be predicted from the significant inter-item correlations of d1d1, d1d2, d1e1, d1e2 and the correlation of all four items with d1a2 (Grid computing is already being used), those companies and institutions already using Grid technologies are characterized by a common attitude. Fifty-eight percent respectively 54% of all surveyed companies responded that the intention to reduce the TCO or increase the QoS would justify the adoption of Grid computing. Thus, as usually more variables are involved in a decision to deploy a new technology, the majority of respondents seem to be rather daring and risk loving because of justifying the use of Grid computing for reducing the TCO or increasing the QoS. According to Heuß' and Rogers' theory, this is an indication that—under the current conditions of the Grid market—mostly risk loving innovators or early adopters are involved in Grid computing research and have adopted Grid technologies already to tackle the challenges in their companies.

5.1.1.2 Public versus Private Sector

An obvious distinction has to be made between companies in the private and institutions in the public sector. Although the significance tests on trial did not reveal significant results (see Ch. 5.2), a different response behavior can still be observed between these two groups. The public sector strongly supports the statements that Grid computing reduces the TCO (100%) and increases the QoS (71%). In contrast, private companies responded rather conservatively (d1d1: 59%; d1e1: 35%).

Several reasons might account for this attitude: Grid computing started out in the research and science environment. Public institutions, therefore, have more experience with this technology, its strengths, and its weaknesses. The private sector still has to find out in which way Grid computing as innovation can support their business in achieving their goals. Moreover, they have to integrate the Grid technology into their existing infrastructures, which is a rather complex and lengthy process.

It can also be argued that research institutions are subject to a pro-innovation bias (see Ch. 2.3), especially since research might be restricted to models and environments that do not reflect actual environments in which businesses operate. Therefore, their perspective is restricted to the assumed model underlying the specific research approach.

Divergent structures of the respective sectors might also influence the more positive attitude of the public sector. Thus, private companies might be under considerable pressure to reduce costs and use available IT budgets effectively and efficiently, especially since the pressure on the management has increased tremendously in the last few years. Within the costs-quality-time paradigm, they are forced to select the right strategy for the first time (Kalakota and Robinson 2001, pp. 109, 143). IT investments are, for this reason, more intensely analyzed. The public sector, on the other hand, can research in predefined environments or with testbeds that are not subject to any external pressures as e.g. the demand for integration with legacy systems. These tests might show clearer results faster than the adoption or implementation in a company could yield.

It can also be observed that the private sector is more reserved regarding the justification of using Grid computing because of the potential to increase the QoS, compared to the more definite attitude towards its use because of the potential to reduce the TCO. Forty-one percent reject deploying Grid because of an increase in QoS, whereas only 18% disagree with using Grid technologies because of its ability to reduce the TCO. Therefore, cost reductions seem to constitute a greater external pressure or justification for adopting Grid technologies.

5.1.1.3 SMEs versus Large Enterprises

Furthermore, company size represented a control variable in our research. Yet, no clear support was to be found that larger companies try Grid computing rather than smaller companies because of a greater amount of financial resources for example. In fact, within the private sector, more SMEs than enterprises were present in the conducted questionnaire. It might be possible that the research communities already contain more SMEs. On the other hand, smaller companies may tend to answer a questionnaire rather than larger companies as the latter might be asked to participate in various surveys.

Another reason might be that the research projects within Grid computing help smaller companies to reduce their knowledge barriers. Within these communities, they find similar peers that can support them if problems arise. In addition, this might indicate that these projects help small companies to overcome missing financial resources. Either the projects are subsidized by governmental organizations or the collaboration of partners reduces the partial costs for research and development activities for each partner involved.

In general, SMEs are more convinced that Grid computing has the potential to reduce the TCO (d1d1; 70%) than enterprises (43%). This supports the great potential of Grid computing especially for smaller companies as they can resort to other resources when needed without investing in additional hardware and reduce the capital lockup, as resources will be utilized more strongly.

Nevertheless, if company size should be tested in the future as influential factor on the adoption of an open Grid, a different research design would be necessary as the conducted survey in this work focused on the attitudes of company representatives with company size as control variable.

5.1.2 Discussion of Key Issues

In the following, the elaborated propositions will be evaluated according to the responses to the questionnaire items.

5.1.2.1 Total Cost of Ownership and Quality of Service

TCO concepts are widely deployed: 71% of the respondents use TCO concepts in their company or institution (d1b1). Of those that responded to whether they use TCO, 55% even agreed that these concepts have a major importance in their company (d1b2).

However, for finding a definite answer to Proposition 1, it has to be clarified if a consistent understanding of TCO concepts is prevalent and for which purposes they are employed. From the presented reasons in Ch. 2.3.3.1, I presume that no uniform understanding exists, as there are different TCO models available on the market (Wild and Herges 2000, p. 9). Although TCO was defined as a tool for managing IT costs and the wording of the question (d1c1) was alluding to the management and evaluation of IT costs specifically, companies could practically deploy TCO as a tool for analyzing investments—with the already described downside of a missing consideration of benefits. Yet, no clear distinction can be derived from the questionnaire which purposes TCO concepts are deployed for in the companies. Thus, this difference in meaning and practical deployment could have influenced the responses of the representatives.

No clear distinction can be made regarding the sufficiency of TCO for the management and evaluation of IT costs since similar answers were given for all three categories (d1c1: "+" 38%, "o" 33%, "-" 29%). Nevertheless, the attitude towards TCO is more clearly within a Grid environment. Sixty-seven percent reject this statement (d1c2). The correlation shows that those who favor TCO for IT costs are of similar opinion regarding TCO for Grid computing. Still, from the 67% that reject TCO for Grid computing, 29% also reject TCO for managing IT-costs. However, a clear difference in responses between d1c1 and d1c2 can be observed. According to

Proposition 2, the actual form of TCO does not seem to be sufficient for Grid computing purposes.

Furthermore, it remains unclear if TCO concepts are not applicable in total or if only additional tools have to be found in order to introduce a value-oriented perspective or to include a cost allocation according to the cause of costs. From a mere conceptual perspective, the TCO concept seems to be rather flexible as the cost accumulation is based on a flexible chart of accounts that might differ from company to company or according to its purpose (e.g. PC, LAN, WAN). Yet, as was also outlined, it was originally introduced to make indirect costs more transparent in decentralized IT infrastructures. However, with the emergence of service-oriented architectures and the consolidation and vertical integration of hardware, managers might have become aware that a shift in management accounting and especially cost allocation to support these technical changes is necessary.

Nevertheless, researchers and practitioners criticized the TCO model because of its lack of contemplating benefits. This critique is not clearly observable in our research. Only the correlation respectively the linear tendency (those that rejected TCO for managing IT costs also disagreed on managing Grid computing costs with TCO) between d1c1 and d1c2 might indicate such an argumentation; especially since 29% rejected both statements. Thus, it could be argued that those that reject both statements reject TCO concepts because of the lack of value-orientation. Still, 17% rejected and 21% remained undecided towards d1c1, but disagreed on managing Grid computing costs with TCO. The latter could be explained by the fact that in practice a value-oriented approach of measuring IT investments is becoming more and more important. Yet, since Grid computing enables the creation if diverse infrastructures, a model for cost- or benefit-analysis of the underlying IT infrastructure and future IT investments have to be customizable to the purposes of the company.

First propositions of activity-based costing or suggestions for cost accounting systems (see Ch. 2.3.3.1) for tackling these challenges were already presented. Within an open Grid market, cost allocation could be manageable through auctions or similar market mechanisms. Still, enterprises have to be able to calculate the costs and evaluate the benefits of their IT infrastructure. Therefore, a more detailed analysis of the outlined problem set in management accounting and the evaluation of IT investments concerning open Grid markets remains necessary in further research.

As was already described in Ch. 5.1.1.1, it can be concluded that specific challenges within the companies' environments exist (e.g. competitive pressures for cost reductions) for which solutions have to be found. Grid computing proposes a solution for these challenges, especially for cost reductions (Proposition 3: Grid computing can be used for reducing TCO). A strong correlation between those using Grid already and those approving of the consequent TCO reduction stresses this fact. However, the respondents were more reserved towards Grid computing for increasing the QoS. Forty-six percent granted Grid computing this potential. Yet, a stronger tendency could be observed towards reducing TCO. This could be an indicator that while costs can be reduced with Grid computing, this might not have a direct effect on service levels as argued in Ch. 2.3.3.1 regarding Proposition 4. Grid computing might therefore not exactly be able to increase the QoS, but it might have the potential to keep existing service levels.

5.1.2.2 Security Issues

Similar to the theoretical findings, security also constitutes an important influential factor from the practitioners' point of view. Almost all respondents support that security is a major factor in utilizing external (d2a1) as well as internal IT services (d2a2) supporting Proposition 5 (Security aspects are important for companies' internal and external usage of Grid computing). Nevertheless, external services (d2b1) are rather an obstacle than internal services (d2b2). Sixty-three percent considered external services being obstructive; 46% rejected this being the case with internal services, which speaks for Proposition 6 (Security concerns hinder the deployment of externally sourced IT services).

Thus, practitioners are even more cautious when selecting external services. Although security mechanisms are being gradually improved, non-technical concerns will also hinder the adoption of Grid resources. As revealed in Ch. 2.3, corporate cultures or personal perceptions of security-aspects are important influential factors that need to be considered.

Furthermore, SMEs and enterprises slightly differed in their attitude towards internal services and their corresponding security-concerns (see Figure 4-4, p. 62). None of the representatives of SMEs viewed security-concerns being influential when sourcing IT services within one's company. However, 43% of the enterprises were more skeptical and saw possible obstacles in using internal IT services.

The perceived security risks and obstacles mark an important factor in Grid adoption especially in an open Grid market and could significantly hinder the adoption. Not only is the existence of hard security necessary, but also soft security has to be enclosed. Since Grid computing is concerned with direct access to remote resources, service or resource provider and the respective users, therefore, have to establish a sufficient level of trust. For this reason, technical security solutions also have to offer possibilities for market participants to establish trust relations amongst each other.

It remains questionable if security concerns are less strongly influencing the adoption decision in Intergrids compared to the adoption of open Grid resources. Theoretically, the level of control is greater in Intergrids, which in turn might positively influence the decision and the attitude of companies towards this form of collaboration. Nevertheless, further research regarding the influence of security concerns towards Intergrids and open Grids has to be undertaken.

Furthermore, 71% of all respondents suggested that Grid computing is suitable for offering standardized services (d2c1) whereas only 46% were of the same opinion regarding Grid computing and customized services (d2c2). Although the relative majority supports the possibility to offer customized services with Grid computing, more representatives were clearly favoring standardized services. Thus, Grid computing seems to be more suitable for standardized services (Proposition 7). This will be especially important in an open Grid market as standardization of services will in turn yield more information for the customer and will reduce the information asymmetry (Eymann et al. 2008, pp. 8-9).

The further examination on reputation and active and passive usage of reputation systems is rather limited. Concerning items d2d2 and d2d3, 42% respectively 50% remained neutral towards these items. One possible explanation would be that these companies and private institutions could not establish a connection between Grid computing and reputational systems as their scope of Grid deployment is still limited to Intragrids. For this reason, it does not seem reasonable to derive detailed conclusions from these items regarding Proposition 8 and Proposition 9 since almost half of the participants would have to be neglected.

Empirically it can be observed that the majority of participants (88%) considered past behavior of sourcing IT services from external service providers (d2d1) as being substantial. Thus, the corporate attitudes regarding reputation mirror the delineated theoretical elaborations.

In addition, the selection of possible reputational systems will also have a specific impact on the reputation of the open Grid market. It could be speculated if the customer would obtain a better overview if partially satisfied users would express their dissatisfaction more clearly (Resnick and Zeckhauser 2002, pp. 23-24). Nevertheless, this might have a negative effect on the overall faith towards the reputational system.

Interestingly, a linear relation existed between those that view security concerns to be an obstacle in service selection (d2b1) and those that would use publicly accessible information about the reputation of the respective supplier (d2d2). Thus, these company representatives would try to reduce their information asymmetry in using a reputational system. This stresses the importance of a reputational system within an open Grid market.

5.1.2.3 Further Requirements

As stated in Proposition 10, the need for a high integration of Grid computing applications into existing systems is clearly supported by the respondents. Eighty-three percent were in favor of this proposition. Thus, a high integration into existing infrastructures will also be a requirement in order to make use of open Grid resources.

Furthermore, Proposition 11 demanded the transparent access of external services. A great majority of 83% supports this statement. Thus, Grid users should only have to deal with the least possible amount of information about the underlying structure.

The most used standard for internal and external communication of companies and institutions being familiar with Grid are Web Services. This might be due to the fact that all respondents are already in contact with Grid computing where the necessity of standards for the interoperability of systems was often stated within numerous researches, especially since Web Services form part of the Grid computing architecture. Especially in an open Grid market does interoperability constitute an important requirement. Otherwise, sharing of resources would not be possible beyond organizational boundaries.

5.2 Evaluation and Limitations of Research Methodology

Generalizing the discussed findings is not unrestrictedly possible. Certain restrictions based on research methodology, instruments or data evaluation therefore limit the informational value.

Firstly, the questionnaire as measuring instrument could have influenced the retained results. All errors due to the measurement method can be described as common method variance (Podsakoff et al. 2003) and are a potential problem in research. First, the content of questions might be one source of error as nine participants were not able to answer especially the first section regarding TCO and QoS. Maybe the questions were too specific so that the respondents were not able to answer. It could also be possible that they could not establish a connection between the items and the topic of Grid computing (e.g. regarding reputation systems). The questions might have reduced the reliability that the questionnaire measures the underlying attribute it was supposed to measure. It is therefore not clear if companies for example are using TCO or using TCO for measuring IT efficiency as the item contains both usage and purpose. Furthermore, the order of items also affects the retained results. Answers to former questions positively or negatively influence the response behavior in a subsequent question (halo effect).

Moreover, the procedure of research might also have influenced the conducted research. It can be observed that only a small sample with 33 respondents was retained. The evaluation of results shows interesting insights. Yet, especially the analysis of private and public institutions or SMEs and enterprises is only based on a small number of respondents. For more-reliable results, the number of retained responses within these specific groups should have been greater. This is also the reason why the tests of significance (see Ch. 4.3.3) do not show any significant results. With a small sample, only large effects can be measured. Some of the α-values were indeed small. Yet, the asymmetry in some of the contingency tables and the few responses did not permit significant results. Nevertheless, difference in answering behavior might still exist which are not based on large but medium effects. These effects would have to be examined with a bigger sample in the future.

Furthermore, the selection of participants might have influenced the results positively. As all of the respondents are part of a research network, the attitude towards Grid computing might be positively biased. Generalizing the results to companies and institutions that are not yet familiar with Grids should therefore be conducted carefully.

The mentioned errors as well as unconsidered variables therefore could have amplified or reduced the examined connections of variables and items. In reality, these connections could be stronger than observed or even non-existent.

5.3 Theoretical Model of Factors Influencing open Grid Adoption

Although the application of the conducted survey is partially limited, some clear tendencies can be used for an application to open Grid markets. As I analyzed the attitude of market actors theoretically and empirically, these findings will now be conflated to propose determinants of open Grids.

From the theoretical findings, it can be concluded that open Grids are still in the experimental phase in which the technology has to be enhanced significantly in order to create demand for such platforms. The determinants that will be elaborated in the following as well as the attitude and concerns of market actors can—in a later stage—be further examined through research and influenced or reduced through practical actions. Thus, the focus is to propose possible influential factors. For this reason, a description why determinants mentioned in Ch. 2.3.2 are not applicable to open Grids does not appear to be beneficial as parameters should be examined that have a positive or negative influence on the attitude towards open Grids and the intention to utilize this form of resource sharing. Nevertheless, factors might have different effects in different stages of the market and might also have mutual impacts. These would have to be examined in further research.

The intention to adopt open Grids within one's company becomes the dependent variable. In the following, the proposed influential factors will be arranged by technological, organizational, and environmental factors.

5.3.1 Technological

Relative Advantage. Although a tendency of pro-innovation bias towards Grid computing can be observed (see Ch. 2.3.1) since numerous publications glorified Grid computing as being the next Internet, the Grid capabilities and the retained responses still suggest a relative advantage compared to existing technologies. The conducted research furthermore stresses Grid computing's capability to reduce the TCO and—less strongly—to increase the QoS. With the emergence of an open Grid market, the flexibility in IT sourcing will increase and will offer, especially to SMEs and Start-Ups, the possibility to source computing resources according to demand. Thus, capital lockup will decrease and the barrier of needed financial resources will diminish. In Intragrids a higher utilization rate of resources can already be achieved, but depending on the growth rate of the company, the number of possible consumers (departments) is rather limited. Offering an open market to data centers for example would increase the number of consumers and the number of demand. Therefore, the utilization rate could further increase, especially if the respective department is accountable for profits and forced to increase the profits. Nevertheless, also higher cost-efficiency is an important factor, not only in Intragrids but also in open Grids. Hence:

> Hypothesis 1: The greater the perceived relative advantage, the greater will be the intention to adopt open Grid resources.

Security Concerns. Nevertheless, the high security concerns regarding external IT-services could have a negative effect on the adoption of an open Grid within one's company. However, as already discussed, security issues are two-fold, including hard and soft factors. Thus, the technical issues have to be solved in order to reach market maturity of the underlying technology or platform. On the other hand, perceived security issues that are mainly based on intuition and belief pose another threat on the adoption of open Grid resources. This was also indicated by the conducted survey.

Some enterprises respondents already denoted security concerns being obstructive within the company. Consequently, the potential perceived threat increases using open Grid resources. Hence:

> Hypothesis 2: The greater the perceived security risks in an open Grid market, the smaller will be the intention to adopt open Grid resources.

In this context, trust in the platform could be used as a more general term that would influence the decision to adopt or to take part in an open Grid market. Nevertheless, a clear understanding of trust has to be developed first in order to derive an exact hypothesis for this variable. This might also depend on market regulations concerning infringements or the choice and design of a possible reputation system in order to decrease information asymmetry. Trust could also be seen in the context of inter-organizational relations. Thus, the reputation of suppliers within the market could have positive or negative effects on the reputation of the platform as described above. Further research therefore seems to be necessary in order to introduce trust and reputation issues into an open Grid platform in this experimental stage of the platform, technically as well as theoretically.

Compatibility. The compatibility of the open Grid technology with existing systems within companies determines the intention whether to use open Grids. As can be derived from the survey results, a high integration with existing systems is necessary. However, compatibility can also be viewed in the context of compatibility with existing management techniques and beliefs. If open Grids demand many changes within a company, the intention to adopt might decrease. The use of service-oriented architectures and the need to analyze IT investments according to their benefits also requires a change in management accounting as shown above. The more open-minded a company is towards these changes and the more changes have been undertaken in a similar direction as Grid computing, the greater will be the compatibility. Therefore:

> Hypothesis 3: The greater the compatibility of Grid computing with existing techniques and beliefs within a company, the greater will be the intention to adopt open Grid resources.

Complexity. In addition, the complexity of the needed technology will affect the implementation and integration processes within a company. The more complex open Grids are, the more knowledge is needed in order to implement open Grids. Additionally, interferences with existing systems need to be eliminated and further training will be necessary. All of these will be more difficult and more costly, if open Grids are too complex. The simpler open Grids are constructed and the easier they can be used and integrated, the more companies will utilize open Grids. Hence:

> Hypothesis 4: The greater the complexity of open Grids, the smaller the intention to adopt open Grid resources.

5.3.2 Organizational

Absorptive Capacity. From an organizational perspective in this market stage, as the Grid technology is still technically developed, the IT department of a company plays an important role in the adoption of Grid technologies, especially as they will mainly be responsible for introducing new infrastructures in their company. Moreover, Grid computing demands a certain amount of technical expertise and, thus, represents a high knowledge burden. However, the IT department can be characterized by different determinants and is probably differently structured in each company. Therefore, the ability to absorb and to assimilate this knowledge into the company system (Fichman 1992; see Ch. 3.4)—the so-called absorptive capacity—might be a better indicator for the decision of adoption. The absorptive capacity is defined as the "ability to exploit external knowledge" (Cohen and Levinthal 1990, p. 128) and is viewed as a function of prior knowledge. R&D investments, employee vocational training, or manufacturing processes are viewed as some of the influential factors of building further capacity. Hence:

> Hypothesis 5: The greater the absorptive capacity of a company, the greater will be the intention to adopt open Grid resources.

Risk Tolerance. Regarding Heuß' conclusions and the findings from diffusion theory, risk tolerance is an important element affecting decision-making. The questionnaire results support this fact, as the current participants in Grid technologies tend to show a high affinity for the new technology and its potential to solve their current business challenges (here cost reduction including service levels in terms of QoS). Therefore, in the early market phases, a high risk-willingness will constitute an important factor on the decision to adopt a technology. Therefore, it can be concluded:

> Hypothesis 6: The greater the risk tolerance, the greater will be the intention to adopt open Grid resources.

In a later stage of the market, though, other factors (e.g. external pressures) will affect immobile entrepreneurs forcing them to adopt the innovation. Consequently, risk tolerance will loose its influence over time. External pressures will be considered within the environmental factors.

Size. Since organizations are very heterogeneous, size was found to be a predictor variable for innovation diffusion and adoption (Chwelos et al. 2001, pp. 305-306; Premkumar et al. 1997, p. 117). Yet, the results of the conducted questionnaire could not support a certain tendency. However, this might not be an indicator, as the study cannot make any inferences on how many small or large companies are utilizing Grid technologies so far. Therefore, I presume that size does still have a positive effect on the adoption of open Grid resources since larger companies dispose of higher financial resources and tend to have lower knowledge barriers (Thong 1999).

> Hypothesis 7: The larger a company, the greater will be its intention to adopt open Grid resources.

Top management support. As research on EDI revealed, top management support is an important influential factor that decides whether a new technology will be adopted as top management support is an indicator for the available financial resources and the commitment for an innovation. Moreover, this construct is similar to Heuß' and Rogers' findings of market actor characteristics. Innovators and early adopters are rather progressive entrepreneurs that foresee strategic possibilities. If the management is committed and confident about the prospects of open Grids, they might also show support for the use of open Grid resources. Therefore:

> Hypothesis 8: The greater the top management support for using an open Grid market, the greater will be the intention to adopt open Grid resources.

5.3.3 Environmental

Number of knowledge barrier-reducing institutions. Moreover, it can be concluded from Ch. 2.2 that institutions for lowering knowledge barriers as consulting companies respectively change agents are important for the diffusion of innovations. Many consulting institutions for Grid computing emerged in the last few years (see Ch. 2.3) that are highly involved in practical research and corresponding research networks, as can be concluded from the conducted questionnaire. The influence they have through their personal networks affects the attitude of their clients. However, only progressive entrepreneurs or innovators are assertive and technology-affine enough to deal with technological challenges and the imposed knowledge barriers. Early adopters on the other hand will examine an innovation more closely and decide subsequently about its usefulness. Their opinion leadership will clearly influence adopters in a later stage. The more support they have to deal with challenges, the stronger will they tend to adopt the innovation. This is especially the case for small companies with limited IT know-how (Premkumar et al. 1997, p. 116). Hence, it can be concluded that:

> Hypothesis 9: The more institutions are actively reducing knowledge barriers regarding an open Grid market, the greater will be the intention to adopt open Grid resources.

Competitive Pressure. In a changing market environment (see Ch. 2.2), cost reductions become important in order to remain competitive. From the obtained responses concerning the potential of Grid computing technologies to reduce the TCO or increase the QoS, I concluded that companies are under competitive pressures, which induce the necessity for cost reductions. This is also the case in the expansion phase of a market (here the market in which a company is offering its products), in which cost reductions become possible as production increases. Yet, in a competitive environment, which requires keeping or increasing one's market share, cost reductions will be inescapable in order to reduce prices or to be profitable. Thus, competitive pressures might also affect the intention to adopt open Grid resources if further cost reductions can be induced through open Grids. Therefore:

> Hypothesis 10: The greater the competitive pressure, the greater will be the intention to adopt open Grid resources.

Network Effect. The critical mass might be an indicator in a later stage of the market as bandwagon effects have a strong influence in network industries (Shy 2001). After the critical mass is reached, the number of users increases exponentially. Still, this variable is only a static indicator. More generally, it can be stated that the more businesses take part in an open Grid market, the more resources will be shared. Thus, the possibilities within the open Grid market will increase. For this reason, the network effect also constitutes an influential factor.

> Hypothesis 11: The greater the network effect, the greater will be the intention to adopt open Grid resources.

Figure 5-1 consequently summarizes all proposed determinants.

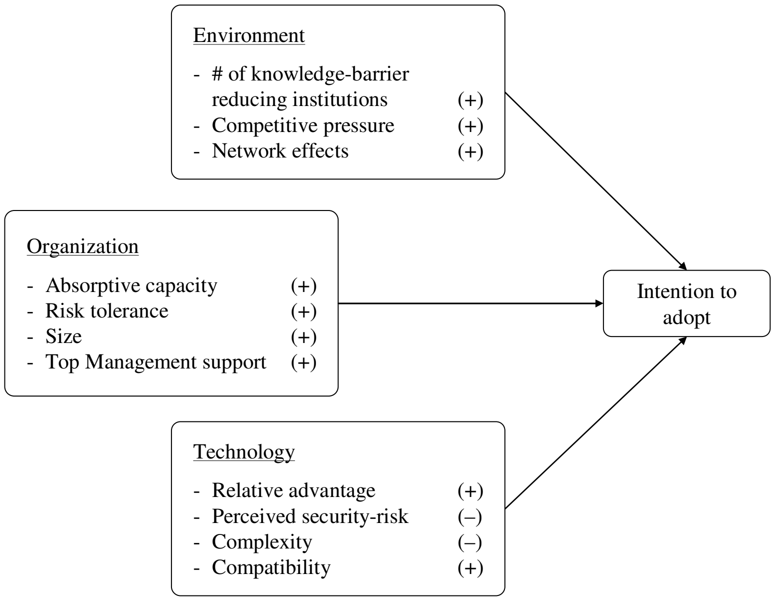

Figure 5-1. Theoretical model on the intention to adopt open Grid computing (Source: Author)

5.4 Implications

As can be concluded from the generalizations of innovation diffusion research, adopters are influenced in different stages by different instruments and strategies (Fichman 1992, p. 2). As the open Grid market and its underlying technology is still in the experimental stage of a market, technological enhancements in order to achieve product maturity are the most important factor in this phase. Thus, it is important to closely work together with eager innovators respectively businesses in order not only to derive the necessary functionality but also to persuade companies of the benefit of an open market platform, especially since the experiences of innovators as well as early adopters determine the image and the future of the newly developed product.

Whereas innovators are technology-affine, early adopters rather see the benefits of the given innovation in their line of action and base their buying decision mostly on their own intuition and vision. They are a key factor in penetrating the market (Moore

1999, p. 12). Thus, after the technological maturity is reached, marketing and penetration of early adopters will become necessary in order to drive the adoption of open Grid resources.

Although different benefits—such as a greater amount of available resources for example—can be mentioned, the corporate attitude towards Grid computing and consequently an open Grid market is a highly influential factor. Especially perceived security concerns can jeopardize the future of an open Grid platform. Thus, it will be necessary to reduce these concerns during the very first phases of the open Grid market (experimentation and expansion).

In addition to technical changes, adjustments to—for example—management accounting or other departments of a company will become necessary if Grid computing and open Grids will be deployed. Therefore, these changes will especially be challenging for change resistant entrepreneurs and reactive or conservative companies.

The proposed model of determinants to adopt open Grid resources represents a sound tool for practitioners as well as researchers. The described findings can therefore be used to enhance the open Grid platform and the proposed determinants can be analyzed for accuracy in further research.

6 Conclusion

As outlined above, the increasing pressure on companies to react flexibly to market changes and stakeholder needs affects IT infrastructures in companies tremendously. IT has therefore become an important competitive factor. In this context, Grid computing proposes to horizontally integrate existing hardware. Consequently, higher utilization rates and less capital lockup are possible. Although Grid computing seems to offer a viable solution to some of the problems posed in this context, its diffusion is still significantly below of what could reasonably be expected.

The contribution of this paper to ongoing research is to define requirements for an open Grid market platform and to identify possible obstacles that hinder the deployment of open Grids in order to help reducing them in the future.

As many commercial Grid solutions are mainly deployed within single organizations, an explorative study with experienced companies and institutions within Grid computing research networks was conducted. The study focused on the attitude of companies and institutions towards economic and security-related aspects.

It was demonstrated that competitive pressures influence companies significantly. They are searching for possible IT solutions that help solving these challenges. Grid computing can therefore be seen as potential tool in order to reduce TCO without sacrificing QoS levels. Nevertheless, commercial institutions remain conservative towards the potential of Grid computing to reduce the TCO or increase the QoS. Grid computing still has yet to prove itself in commercial environments.

Moreover, security concerns hinder the deployment of open Grids tremendously. Not only technical challenges account for this fact, also soft security issues as reputation and trust have to be considered in open Grid platforms. Those that foresee potential security obstacles when sourcing external IT services tend to utilize reputation systems in order to reduce their uncertainty.

In addition, Grid computing is specifically viewed to be suitable for standardized services. A high integration with existing systems and transparent access of external resources are demanded. Furthermore, Web Services were the most known and used standard among the respondents.

In general, it can be concluded that intra-organizational Grid solutions are already in the phase of early adoption whereas open Grids still remain in the experimental stage. Although some would point out a chasm between early adopters and the mass market for Grid computing, no such chasm could be deducted. The needed efforts to create further demand in the early adopters' stage are rather lengthy and laborious. Regarding open Grid platforms, technological maturity in order to create demand for open Grid resources constitutes a key element for the success of this platform in its current stage. Nevertheless, corporate concerns have to be reduced and a close cooperation with opinion leaders is advised so that additional functionalities can be added and the open market platform can be promoted amongst commercial customers. Marketing actions and the search for important opinion leaders will be crucial later in the expansion phase in order to reduce uncertainty and objection against an open Grid platform. This paper at hand and the developed theoretical model of determinants on the intention to adopt open Grid resources therefore hopefully present a sound basis and guidance for theoretical and practical actions in the future.

Appendix

A Scatter plot

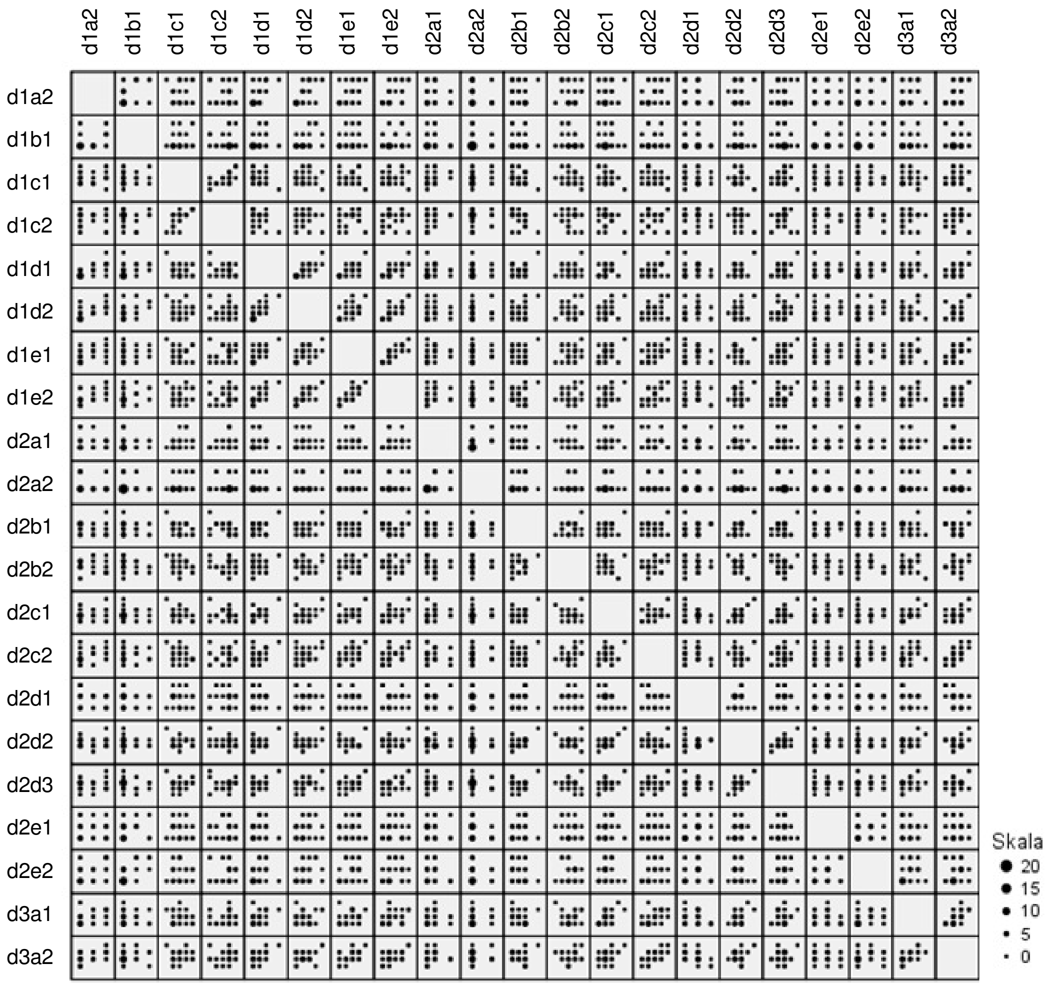

Figure A-1. Scatter plot across all items

All categories that obtain more than a certain amount of responses were grouped in this figure and are represented by a dot that increases in size according to the number it represents (see legend to the right). d1a1 and d1b2 were excluded as already mentioned in Ch. 3.4.3 (Source: Author)

C E-Mail Invitation

Dear [redacted]

being member of the EU-project SORMA (http://www.sorma-project.org/), we're currently conducting a survey regarding the attitude of companies towards Grid Computing. Subsequently, we tend to derive user requirements for the market platform being developed.

For this reason, we're especially looking for businesses that would participate in this short online survey which can be found at http://www.wi.uni-bayreuth.de/sorma/survey/en. We would be very grateful if you could help us in contacting the in NextGRID participating companies.

The responses will of course remain confidential. Also, only anonymous data will be used for publishing purposes. If desired, each participant will receive the processed results when the study is completed.

Yours sincerely,

(Source: Author)

D Survey

The questionnaire was conducted online. The online version was accessible via http://www.wi.uni-bayreuth.de/sorma/survey/en. Two items were presented on one page (e.g. part 1A; see Figure D-1).

D.1 Questionnaire

Figure D-1. SORMA questionnaire (Page 1 of 6)

SORMA Evaluation http://132.180.40.189/survey152/admin/admin.php?action=showprinta...

SORMA - Self-Organizing ICT Resource Management

Grid Computing Requirements Survey in the context of project SORMA

1A

*** 110: I'm familiar with the idea of Grid computing.**

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

*** 115: Grid computing infrastructures are already being used in my enterprise.**

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

1B

110: Total Cost of Ownership concepts are being used in my business in order to evaluate the efficiency of IT investments.

Total Costs of Ownership (TCO) designates the total cost of owning technology resources, including initial purchase costs, the cost of hardware and software upgrades, maintenance, technical support, and training.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

115: TCO-calculations are of major importance in my business.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

1C

110: TCO concepts are sufficient for the evaluation and the management of IT-costs.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree

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Figure D-1. SORMA questionnaire (Page 2 of 6)

Strongly Disagree

115: TCO concepts are sufficient for the evaluation and the management of Grid computing expenditures.

Please choose *only one* of the following:
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

1D

110: Grid computing has the potential to reduce the TCO.

Please choose *only one* of the following:
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

115: The intention to reduce TCO justifies the use of Grid computing applications in my business.

Please choose *only one* of the following:
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

1E

110: Grid computing has the potential to improve the Quality of Service (QoS).

Quality of service describes packet delivery guarantees provided by a network architecture (e.g. LAN or WAN). Usually related to performance guarantees, such as bandwidth and delay.

Please choose *only one* of the following:
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

115: The intention to increase the QoS justifies the use of Grid computing applications in my business.

Please choose *only one* of the following:
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

2A

Figure D-1. SORMA questionnaire (Page 3 of 6)

110: Security has a high priority when using in-house IT-services.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

115: Security has a high priority when using external IT-services.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

2B

110: Security concerns are an obstacle for the acquisition of IT-services by an external service provider.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

115: Security concerns are an obstacle for the acquisition of IT-services by a department service provider.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

2C

110: Grid computing applications are suitable for offering standardized services.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

115: Grid computing applications are suitable for offering customized services.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Figure D-1. SORMA questionnaire (Page 4 of 6)

2D

110: Information about the past behaviour of external IT-service providers is important for the service selection.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

115: I would use publicly accessible information (e.g. in form of an ebay-like evaluation system) for the service selection.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

120: I would publicly make available my personal experience regarding the trustworthiness of service providers.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

2E

110: The following standards for internal and external communication are being used in my business.

Please choose *all* that apply:

- SOA Standards
- Web Services
- CORBA
- Individual XML messages
- EDI
- Idoc
- Java messages
- Component-based messages

Other:

115: A high integration of grid computing applications into existing implementations is important.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Figure D-1. SORMA questionnaire (Page 5 of 6)

SORMA Evaluation http://132.180.40.189/survey152/admin/admin.php?action=showprinta...

120: External services should be accessed transparently.

Regardless of how resource access and representation has to be performed on each individual computing entity, the users of a Grid computing system should always access resources in a single, uniform way.

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

3

*** 110: In the future, Grid computing will play a decisive role in the IT sector.**

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

*** 115: In the future, Grid computing will play a decisive role in my business.**

Please choose *only one* of the following:

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

*** 120: Which industrial sector does your business belong to?**

Please write your answer here:

*** 125: How many employees work for your business?**

Please choose *only one* of the following:

- 1-10
- 11-50
- 51-250
- 251-500
- 501-1000
- >1000

*** 130: In which department do you work?**

Please write your answer here:

*** 135: Which role does your business play with regard to Grid computing?**

Please choose *all* that apply:

- IT-Service Provider
- Application Provider
- IT-Service Consumer

Figure D-1. SORMA questionnaire (Page 6 of 6)

SORMA Evaluation http://132.180.40.189/survey152/admin/admin.php?action=showprinta...

Other:

*** 140: Which country are you from?**

Please write your answer here:

145: Leave us your email if you are interested in the survey results

Please write your answer here:

Submit Your Survey.

Thank you for completing this survey. Please fax your completed survey to: .

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(Source: Author, based on printout of LimeSurvey-software 1.52)

D.2 Item Description

Table D-1. Summary of propositions and survey items

Category	Proposition	Description of Proposition	Item	Description of Item
			d1a1	I'm familiar with the idea of Grid computing.
			d1a2	Grid computing infrastructures are already being used in my enterprise.
Economic Aspects	Proposition 1	TCO concepts are deployed since being important for the evaluation of the profitability of IT investments	d1b1	Total Cost of Ownership concepts are being used in my business in order to evaluate the efficiency of IT investments.
			d1c2	TCO-calculations are of major importance in my business. (N=22)
	Proposition 2	TCO concepts in their actual form are not sufficient for the deployment in Grid computing	d1c1	TCO concepts are sufficient for the evaluation and the management of IT-costs.
			d1c2	TCO concepts are sufficient for the evaluation and the management of Grid computing expenditures.
	Proposition 3	Grid computing can be used for reducing TCO	d1d1	Grid computing has the potential to reduce the TCO.
			d1d2	The intention to reduce TCO justifies the use of Grid computing applications in my business.
	Proposition 4	Grid computing can be used to increase the Quality of Service (QoS)	d1e1	Grid computing has the potential to improve the Quality of Service (QoS).
			d1e2	The intention to increase the QoS justifies the use of Grid computing applications in my business.
Security-related and Technical Aspects	Proposition 5	Security aspects are important for companies' internal and external usage of Grid computing	d2a1	Security has a high priority when using in-house IT-services.
			d2a2	Security has a high priority when using external IT-services.
	Proposition 6	Security concerns hinder the deployment of externally sourced IT services	d2b1	Security concerns are an obstacle for the acquisition of IT-services by an external service provider.
			d2b2	Security concerns are an obstacle for the acquisition of IT-services by a department service provider.
	Proposition 7	Grid computing is more suitable for standardized services than individual services	d2c1	Grid computing applications are suitable for offering standardized services.
			d2c2	Grid computing applications are suitable for offering customized services.
	Proposition 8	Feedback rating systems are important for the selection of IT service providers	d2d1	Information about the past behaviour of external IT-service providers is important for the service selection.
			d2d2	I would use publicly accessible information (e.g. in form of an ebay-like evaluation system) for the service selection.
	Proposition 9	No differences exist between passive and active usage of public feedback rating systems	d2d3	I would publicly make available my personal experience regarding trustworthiness of service providers.
	Proposition 10	A high integration of Grid computing applications into existing implementations is important	d2e2	A high integration of grid computing applications into existing implementations is important.
	Proposition 11	External services should be accessed transparently	d2e3	External services should be accessed transparently.
Future expectations			d3a1	In the future, Grid computing will play a decisive role in the IT sector.
			d3a2	In the future, Grid computing will play a decisive role in my business.
Demographic Variables			d3b1	Which industrial sector does your business belong to?
			d3b2	How many employees work for your business?
			d3b3	In which department do you work?
			d3b4	Role of company in Grid computing: (IT-service provider, IT-application provider, IT-service consumer, other)
			d3b5	Country

E Industrial Sectors and NACE codes (European Commission 2008)

Table E-1. Clustered Industrial Sectors for Data Analysis

NACE code	Description	Analysis Cluster
DK.29.00	Manufacture of machinery and equipment n.e.c.	Machinery and Engineering
DM.34.00	Manufacture of motor vehicles, trailers and semi-trailers	Automotive
DM.34.30	Manufacture of parts and accessories for motor vehicles and their engines	
I.62.00	Air transport	Air transport
I.64.20	Telecommunications	Telecommunications
J.65.12	Other monetary intermediation	Finance / Banking
K.72.22	Other software consultancy and supply	Software development
K.73.10	Research and experimental development on natural sciences and engineering	Research
K.74.14	Business and management consultancy activities	Consulting
M.80.30	Higher education	University
N.85.10	Human health activities	Health

(Source: Author, based on European Commission (2008))

F Data Tables

F.1 Correlations

Table F-1. Inter-Item Correlations

		Kendall's tau(b) I N=24	d1a1	d1a2	d1b1	d1b2	d1c1	d1c2	d1d1	d1d2	d1e1	d1e2	d2a1	d2a2	d2b1	d2b2	d2c1	d2c2	d2d1	d2d2	d2d3	d2e2	d2e3	d3a1	d3a2
d1a1	Familiar with Grid computing (grouped)	Correlation Coefficient																							
		Sig. (2-tailed)																							
d1a2	Grid computing infrastructures already in use (grouped)	Correlation Coefficient		1																					
		Sig. (2-tailed)		.																					
d1b1	Total Cost of Ownership concepts are being used in my business in order to evaluate the efficiency of IT investments.	Correlation Coefficient		0.44	1																				
		Sig. (2-tailed)		0.02	.																				
d1c1	TCO concepts are sufficient for the evaluation and the management of IT-costs.	Correlation Coefficient		0.10	0.02		1																		
		Sig. (2-tailed)		0.59	0.91		.																		
d1c2	TCO concepts are sufficient for the evaluation and the management of Grid computing expenditures.	Correlation Coefficient		0.01	0.06		0.57	1																	
		Sig. (2-tailed)		0.98	0.75		0.00	.																	
d1d1	Grid computing has the potential to reduce the TCO.	Correlation Coefficient		0.63	0.28		-0.20	-0.19	1																
		Sig. (2-tailed)		0.00	0.11		0.26	0.28	.																
d1d2	The intention to reduce TCO justifies the use of Grid computing applications in my business.	Correlation Coefficient		0.62	0.26		0.00	0.04	0.71	1															
		Sig. (2-tailed)		0.00	0.14		0.98	0.82	0.00	.															
d1e1	Grid computing has the potential to improve the Quality of Service (QoS).	Correlation Coefficient		0.42	0.06		-0.03	0.13	0.57	0.46	1														
		Sig. (2-tailed)		0.02	0.72		0.87	0.44	0.00	0.01	.														
d1e2	The intention to increase the QoS justifies the use of Grid computing applications in my business.	Correlation Coefficient		0.53	0.14		0.08	0.13	0.64	0.72	0.74	1													
		Sig. (2-tailed)		0.00	0.42		0.65	0.47	0.00	0.00	0.00	.													
d2a1	Security has a high priority when using in-house IT-services.	Correlation Coefficient		0.01	0.01		0.31	0.18	0.20	0.07	0.26	0.28	1												
		Sig. (2-tailed)		0.95	0.98		0.10	0.33	0.28	0.71	0.15	0.13	.												
d2a2	Security has a high priority when using external IT-services.	Correlation Coefficient		-0.18	-0.18		0.18	0.10	-0.07	-0.01	0.06	0.17	0.41	1											
		Sig. (2-tailed)		0.36	0.34		0.35	0.62	0.71	0.97	0.75	0.38	0.04	.											
d2b1	Security concerns are an obstacle for the acquisition of IT-services by an external service provider.	Correlation Coefficient		-0.17	-0.31		-0.31	-0.42	0.08	0.14	-0.08	-0.01	-0.16	0.10	1										
		Sig. (2-tailed)		0.35	0.08		0.08	0.02	0.67	0.43	0.66	0.96	0.38	0.59	.										
d2b2	Security concerns are an obstacle for the acquisition of IT-services by a department service provider.	Correlation Coefficient		-0.07	-0.21		-0.21	-0.03	0.00	-0.04	0.10	0.03	-0.24	0.06	0.14	1									
		Sig. (2-tailed)		0.69	0.22		0.22	0.87	1.00	0.83	0.56	0.85	0.20	0.75	0.44	.									
d2c1	Grid computing applications are suitable for offering standardized services.	Correlation Coefficient		0.10	0.01		-0.22	-0.18	0.36	0.25	0.33	0.32	0.27	0.07	0.21	-0.15	1								
		Sig. (2-tailed)		0.60	0.98		0.22	0.31	0.05	0.15	0.06	0.07	0.15	0.71	0.24	0.38	.								
d2c2	Grid computing applications are suitable for offering customized services.	Correlation Coefficient		0.32	0.06		-0.20	0.03	0.39	0.25	0.38	0.38	-0.01	0.08	0.00	0.26	0.29	1							
		Sig. (2-tailed)		0.07	0.72		0.24	0.85	0.03	0.15	0.03	0.03	0.98	0.69	0.98	0.14	0.10	.							
d2d1	Information about the past behaviour of external IT-service providers is important for the service selection.	Correlation Coefficient		-0.17	-0.18		-0.08	-0.02	0.03	0.13	-0.08	0.05	-0.12	0.03	0.26	-0.09	-0.16	-0.08	1						
		Sig. (2-tailed)		0.36	0.33		0.65	0.93	0.88	0.48	0.67	0.80	0.52	0.90	0.17	0.63	0.40	0.67	.						
d2d2	I would use publicly accessible information (e.g. in form of an ebay-like evaluation system) for the service selection.	Correlation Coefficient		-0.01	-0.19		0.01	-0.16	0.05	0.11	-0.25	-0.03	-0.16	-0.19	0.38	-0.05	0.39	-0.17	0.14	1					
		Sig. (2-tailed)		0.98	0.31		0.95	0.38	0.79	0.53	0.17	0.86	0.41	0.33	0.04	0.78	0.04	0.35	0.47	.					
d2d3	I would publicly make available my personal experience regarding trustworthiness of service providers.	Correlation Coefficient		0.06	-0.20		0.09	0.14	0.21	0.22	0.27	0.25	-0.04	-0.16	-0.02	-0.12	0.30	0.07	0.11	0.38	1				
		Sig. (2-tailed)		0.73	0.27		0.61	0.43	0.24	0.21	0.13	0.16	0.81	0.42	0.91	0.52	0.10	0.67	0.57	0.04	.				
d'2e2	A high integration of grid computing applications into existing implementations is important.	Correlation Coefficient		0.01	0.29		-0.21	-0.10	0.12	0.16	0.06	0.10	-0.05	-0.30	0.19	-0.15	0.27	0.05	0.31	0.11	0.07	1			
		Sig. (2-tailed)		0.95	0.12		0.25	0.60	0.53	0.39	0.76	0.57	0.79	0.13	0.30	0.41	0.14	0.80	0.11	0.57	0.70	.			
d2e3	External services should be accessed transparently.	Correlation Coefficient		0.32	0.46		0.07	0.18	0.32	0.29	0.26	0.25	-0.10	-0.07	-0.26	-0.09	0.13	0.27	0.05	-0.13	0.11	0.19	1		
		Sig. (2-tailed)		0.09	0.01		0.69	0.32	0.08	0.11	0.14	0.16	0.59	0.73	0.17	0.63	0.48	0.13	0.79	0.49	0.55	0.31	.		
d3a1	In the future, Grid computing will play a decisive role in the IT sector.	Correlation Coefficient		0.26	0.04		-0.05	0.09	0.27	0.07	0.24	0.29	0.14	0.09	-0.26	0.14	0.47	0.46	-0.21	0.22	0.14	-0.09	0.31	1	
		Sig. (2-tailed)		0.16	0.82		0.78	0.63	0.14	0.68	0.17	0.10	0.45	0.65	0.15	0.42	0.01	0.01	0.26	0.24	0.45	0.64	0.09	.	
d3a2	In the future, Grid computing will play a decisive role in my business.	Correlation Coefficient		0.44	0.12		0.09	0.16	0.38	0.24	0.42	0.45	0.12	0.01	-0.17	0.14	0.30	0.53	-0.38	-0.04	0.11	-0.08	0.29	0.61	1
		Sig. (2-tailed)		0.02	0.51		0.63	0.37	0.04	0.18	0.02	0.01	0.51	0.97	0.35	0.45	0.10	0.00	0.04	0.84	0.56	0.66	0.13	0.00	.

F.2 Contingency Table (Private versus Public)

Table F-2. Contingency table of items segmented by private / public sector as well as SME / enterprises

Items		**Private**			**Public**			**Total**
(Part I)		SME	>250	**Total**	SME	>250	**Total**	
		%	%	%	%	%	%	%
d1c1	+	40	57	**47**	33	0	**14**	38
	o	20	29	**24**	33	75	**57**	33
	-	40	14	**29**	33	25	**29**	29
d1c2	+	30	29	**29**	0	0	**0**	21
	o	0	14	**6**	0	50	**29**	13
	-	70	57	**65**	100	50	**71**	67
d1d1	+	70	43	**59**	100	100	**100**	71
	o	30	43	**35**	0	0	**0**	25
	-	0	14	**6**	0	0	**0**	4
d1d2	+	60	57	**59**	33	75	**57**	58
	o	30	14	**24**	33	25	**29**	25
	-	10	29	**18**	33	0	**14**	17
d1e1	+	40	29	**35**	67	75	**71**	46
	o	30	43	**35**	33	0	**14**	29
	-	30	29	**29**	0	25	**14**	25
d1e2	+	40	57	**47**	67	75	**71**	54
	o	20	0	**12**	0	25	**14**	13
	-	40	43	**41**	33	0	**14**	33
d2a1	+	100	86	**94**	67	75	**71**	88
	o	0	0	**0**	0	0	**0**	0
	-	0	14	**6**	33	25	**29**	13
d2a2	+	100	100	**100**	100	100	**100**	100
	o	0	0	**0**	0	0	**0**	0
	-	0	0	**0**	0	0	**0**	0
d2b1	+	60	71	**65**	33	75	**57**	63
	o	40	14	**29**	67	25	**43**	33
	-	0	14	**6**	0	0	**0**	4
d2b2	+	0	43	**18**	0	50	**29**	21
	o	50	14	**35**	33	25	**29**	33
	-	50	43	**47**	67	25	**43**	46
Numbers		10	7	17	3	4	7	24

Items		**Private**			**Public**			**Total**
(Part II)		SME	>250	**Total**	SME	>250	**Total**	
		%	%	%	%	%	%	%
d2c1	+	90	43	**71**	67	75	**71**	71
	o	10	29	**18**	33	25	**29**	21
	-	0	29	**12**	0	0	**0**	8
d2c2	+	40	43	**41**	67	50	**57**	46
	o	40	0	**24**	33	25	**29**	25
	-	20	57	**35**	0	25	**14**	29
d2d1	+	90	100	**94**	67	75	**71**	88
	o	10	0	**6**	33	25	**29**	13
	-	0	0	**0**	0	0	**0**	0
d2d2	+	50	57	**53**	33	50	**43**	50
	o	50	14	**35**	67	50	**57**	42
	-	0	29	**12**	0	0	**0**	8
d2d3	+	30	29	**29**	33	75	**57**	38
	o	50	57	**53**	67	25	**43**	50
	-	20	14	**18**	0	0	**0**	13
d2e2	+	100	86	**94**	33	75	**57**	83
	o	0	14	**6**	67	25	**43**	17
	-	0	0	**0**	0	0	**0**	0
d2e3	+	90	86	**88**	67	75	**71**	83
	o	10	14	**12**	33	25	**29**	17
	-	0	0	**0**	0	0	**0**	0
d3a1	+	80	43	**65**	100	100	**100**	75
	o	20	43	**29**	0	0	**0**	21
	-	0	14	**6**	0	0	**0**	4
d3a2	+	50	43	**47**	100	75	**86**	58
	o	40	43	**41**	0	25	**14**	33
	-	10	14	**12**	0	0	**0**	8
Numbers		10	7	17	3	4	7	24

F.3 Significance Test of 3x2 Contingency Tables (Private versus Public Sector)

Table F-3. Significance of 3x2 contingency tables (private and public sectors). H(O;U) represents the null hypothesis regarding independence. $P' = \sum p$ represents the probability of each possible table with the same marginal total. c corresponds to the probability of the table with that the sum of p reaches or exceeds α

d1c1

	Priv	Publ	Total
+	8	1	9
o	4	4	8
-	5	2	7
Total	17	7	24

Reject H(0;U) if: P(n11) < c
P(n11) = 0.0382 > 0.008
Do not reject H0
α= 0.05
c= 0.008

∑ p	p
0%	0.000
0%	0.000
0%	0.000
0%	0.000
0%	0.000
0%	0.001
0%	0.001
0%	0.002
1%	0.002
1%	0.002
1%	0.002
1%	0.003
2%	0.004
2%	0.006
3%	0.006
4%	0.007
4%	0.008
5%	0.008
6%	0.010
7%	0.010
8%	0.013
10%	0.017
12%	0.020
14%	0.020
17%	0.025
20%	0.029
24%	0.038
29%	0.051
34%	0.051
40%	0.061
47%	0.068
54%	0.071
63%	0.095
73%	0.102
86%	0.122
100%	0.143

d1d1

	Priv	Publ	Total
+	10	7	17
o	6	0	6
-	1	0	1
Total	17	7	24

Reject H(0;U) if: P(n11) < c
P(n11) = 0.056 > 0.036
Do not reject H0
α= 0.05
c= 0.036

∑ p	p
0%	0.000
0%	0.000
0%	0.000
0%	0.002
1%	0.006
4%	0.029
7%	0.036
11%	0.039
17%	0.056
27%	0.103
38%	0.107
52%	0.138
73%	0.215
100%	0.268

d1e1

	Priv	Publ	Total
+	6	5	11
o	6	1	7
-	5	1	6
Total	17	7	24

Reject H(0;U) if: P(n11) < c
P(n11) = 0.056 > 0.010
Do not reject H0
α= 0.05
c= 0.010

∑ p	p
0%	0.000
0%	0.000
0%	0.000
0%	0.000
0%	0.000
0%	0.000
0%	0.001
0%	0.001
0%	0.001
0%	0.001
1%	0.002
1%	0.002
1%	0.003
2%	0.004
2%	0.007
3%	0.008
4%	0.009
5%	0.010
7%	0.017
8%	0.017
10%	0.017
12%	0.019
14%	0.020
16%	0.022
19%	0.028
22%	0.033
26%	0.033
31%	0.056
38%	0.067
45%	0.067
53%	0.083
63%	0.100
73%	0.100
85%	0.120
100%	0.150

d1e2

	Priv	Publ	Total
+	8	5	13
o	2	1	3
-	7	1	8
Total	17	7	24

Reject H(0;U) if: P(n11) < c
P(n11) = 0.089 > 0.013
Do not reject H0
α= 0.05
c= 0.013

∑ p	p
0%	0.000
0%	0.000
0%	0.000
0%	0.000
0%	0.001
0%	0.002
1%	0.002
1%	0.005
2%	0.006
2%	0.006
3%	0.007
4%	0.008
5%	0.011
6%	0.013
8%	0.015
11%	0.038
15%	0.040
20%	0.047
25%	0.050
31%	0.058
38%	0.069
47%	0.089
57%	0.104
69%	0.116
83%	0.139
100%	0.174

F.4 Significance Test of 3x2 Contingency Tables (SME versus Enterprises)

Table F-4. Significance test of 3x2 contingency tables (SME versus enterprises). H(O;U) represents the null hypothesis regarding independence. $P' = \sum p$ represents the probability of each possible table with the same marginal total. c corresponds to the probability of the table with that the sum of p reaches or exceeds α

d1c1

	SME	>250	Total
+	4	4	8
o	2	2	4
-	4	1	5
Total	10	7	17

Reject H(0;U) if:	P(n11)	<	c
P(n11) =	0.108	>	0.014
	Do not reject H0		
		α=	0.05
		c=	0.014

∑ p	p
0%	0.000
0%	0.000
0%	0.001
0%	0.001
0%	0.001
1%	0.002
1%	0.003
1%	0.004
2%	0.006
3%	0.007
3%	0.007
4%	0.012
6%	0.014
7%	0.014
9%	0.016
11%	0.017
14%	0.029
16%	0.029
20%	0.036
26%	0.058
32%	0.058
37%	0.058
46%	0.086
57%	0.108
68%	0.115
83%	0.144
100%	0.173

d2b2

	SME	Entpr	
+	0	3	3
o	5	1	6
-	5	3	8
	10	7	17

Reject H(0;U) if:	P(n11)	<	c
P(n11) =	0.017	>	0.009
	Do not reject H0		
		α=	0.05
		c=	0.009

∑ p	p
0%	0.000
0%	0.000
0%	0.000
0%	0.001
0%	0.001
1%	0.004
1%	0.004
2%	0.007
3%	0.008
3%	0.009
4%	0.009
5%	0.009
7%	0.017
9%	0.019
11%	0.022
15%	0.043
20%	0.043
25%	0.052
31%	0.065
38%	0.065
45%	0.072
54%	0.086
67%	0.130
83%	0.162
100%	0.173

d2c1

	SME	>250	Total
+	9	3	12
o	1	2	3
-	0	2	2
Total	10	7	17

Reject H(0;U) if:	P(n11)	<	c
P(n11) =	0.034	>	0.025
	Do not reject H0		
		α=	0.05
		c=	0.025

∑ p	p
0%	0.003
3%	0.023
5%	0.025
9%	0.034
13%	0.041
17%	0.041
24%	0.076
34%	0.095
46%	0.122
60%	0.143
76%	0.153
100%	0.244

d2c2

	SME	Entpr	
+	4	3	7
o	4	0	4
-	2	4	6
	10	7	17

Reject H(0;U) if:	P(n11)	<	c
P(n11) =	0.027	>	0.009
	Do not reject H0		
		α=	0.05
		c=	0.0086

∑ p	p
0%	0.000
0%	0.000
0%	0.000
0%	0.001
0%	0.001
0%	0.002
1%	0.002
1%	0.002
1%	0.003
2%	0.005
2%	0.006
3%	0.006
4%	0.006
4%	0.007
5%	0.009
7%	0.016
9%	0.026
12%	0.027
15%	0.029
18%	0.032
22%	0.036
26%	0.043
33%	0.065
39%	0.065
46%	0.065
56%	0.108
69%	0.130
84%	0.144
100%	0.162

d2d2

	SME	>250	Total
+	5	4	9
o	5	1	6
-	0	2	2
Total	10	7	17

Reject H(0;U) if:	P(n11)	<	c
P(n11) =	0.039	>	0.0259
	Do not reject H0		
		α=	0.05
		c=	0.0259

∑ p	p
0%	0.000
0%	0.000
0%	0.000
0%	0.002
1%	0.006
1%	0.006
2%	0.007
3%	0.009
4%	0.011
7%	0.026
10%	0.037
14%	0.039
20%	0.056
26%	0.065
33%	0.065
41%	0.078
50%	0.097
63%	0.130
81%	0.173
100%	0.194

d3a1

	SME	Entpr	
+	8	3	11
o	2	3	5
-	0	1	1
	10	7	17

Reject H(0;U) if:	P(n11)	<	c
P(n11) =	0.085	>	0.024
	Do not reject H0		
		α=	0.05
		c=	0.024

∑ p	p
0%	0.001
0%	0.003
2%	0.014
3%	0.017
6%	0.024
10%	0.042
19%	0.085
30%	0.119
42%	0.119
59%	0.170
76%	0.170
100%	0.238

F.5 Significance Test of 2x2 Contingency Tables

Table F-5. Significance tests of 2x2 contingency tables (Private versus Public and SME versus enterprises). All tests are one-tailed. For all tables being more extreme than the one that was obtained from the survey the respective probability was calculated (shown under each item number). All probabilities were added. If the sum of these probabilities was greater than the predefined value for α=0.05, the null-hypothesis could not be rejected

Private vs Public

d1c1		Priv	Publ	
0.13015	+	8	1	9
	o / -	9	6	15
		17	7	24
0.01859	+	9	0	9
	o / -	8	7	15
		17	7	24
0.14874				

d1d1		Priv	Publ	
0.05619	+	10	7	17
	o / -	7	0	7
		17	7	24
0.05619				

d1e1		Priv	Publ	
0.10412	+	6	5	11
	o / -	11	2	13
		17	7	24
0.01735	+	5	6	11
	o / -	12	1	13
		17	7	24
0.00095	+	4	7	11
	o / -	13	0	13
		17	7	24
0.12243				

d1e2		Priv	Publ	
0.20452	+	8	5	13
	o/-	9	2	11
		17	7	24
0.05454	+	7	6	13
	o / -	10	1	11
		17	7	24
0.00496	+	6	7	13
	o / -	11	0	11
		17	7	24
0.26402				

d2e2		Priv	Publ	
0.05599	+	16	4	20
	o / -	1	3	4
		17	7	24
0.00329	+	17	3	20
	o / -	0	4	4
		17	7	24
0.05929				

d3a1		Priv	Publ	
0.09195	+	11	7	18
	o / -	6	0	6
		17	7	24
0.09195				

d3a2		Priv	Publ	
0.08677	+	8	6	14
	o / -	9	1	10
		17	7	24
0.00992	+	7	7	14
	o / -	10	0	10
		17	7	24
0.09668				

SME vs Enterprises

d1c1		SME	>250	
0.30234	+	4	4	8
	o / -	6	3	9
		10	7	17
0.10366	+	3	5	8
	o / -	7	2	9
		10	7	17
0.01296	+	2	6	8
	o / -	8	1	9
		10	7	17
0.00041	+	1	7	8
	o / -	9	0	9
		10	7	17
0.41937				

d1d1		SME	>250	
0.21596	+	7	3	10
	o / -	3	4	7
		10	7	17
0.04859	+	8	2	10
	o / -	2	5	7
		10	7	17
0.0036	+	9	1	10
	o / -	1	6	7
		10	7	17
5.1E-05	+	10	0	10
	o / -	0	7	7
		10	7	17
0.2682				

d2b2		SME	>250	
0.05147	+	0	3	3
	o / -	10	4	14
		10	7	17
0.05147				

d2c1		SME	>250	
0.05656	+	9	3	12
	o / -	1	4	5
		10	7	17
0.00339	+	10	2	12
	o / -	0	5	5
		10	7	17
0.05995				

d3a1		SME	>250	
0.12726	+	8	3	11
	o / -	2	4	6
		10	7	17
0.01697	+	9	2	11
	o / -	1	5	6
		10	7	17
0.00057	+	10	1	11
	o / -	0	6	6
		10	7	17
0.1448				

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List of Abbreviations

A	agree
B2B	business-to-business
CDISC	Clinical Data Interchange Standards Consortium
Ch.	Chapter
D	disagree
HL7	Health Level 7
ICT	information and communications technology
IT	information technology
N	neutral
NACE	Nomenclature des activités économiques dans la Communauté Européenne
OGC®	Open Geospatial Consortium
OGSA	Open Grid Services Architecture
QoS	Quality of Service
ROI	return-on-investment
SA	strongly agree
SD	strongly disagree
SME	small- and medium-sized enterprises
SOA	Service Oriented Architecture
SORMA	Self-Organizing ICT Resource Management
TCO	Total Cost of Ownership
VO	Virtual Organization

(For a list of all items used in the survey, please refer to Appendix D.2)

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As Grid computing commenced in the scientific sector, it slowly enters the commercial environment. Although it proposes interesting features for horizontal integration of hardware and resource sharing, businesses slowly implement Intragrids in their companies. Open Grid markets are yet not deployed. The thesis at hand tries to bridge the gap between Intra- and open Grids. An explorative study surveyed Grid experts towards economic and security-related aspects. Accordingly, Grid computing has the potential to reduce the total costs without sacrificing service levels. Yet, subjective assessments of security issues still hinder the deployment. Therefore, a theoretical model of determinants is derived and needed user requirements are presented in order to positively influence the diffusion of open Grids.

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